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COMMAND AND CONTROL TEAMS: TECHNIQUES FOR ASSESSING TEAM PERFORMANCE

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The Air Force uses tactical command and control C^2 systems to task and manage theater combat missions and responses to crisis situations. While current and planned C^2 systems are heavily dependent on teams which operate elements of the system, team performance has not been formally studied or recognized as important. To partially address this situation, the Air Force Human Resources Laboratory has begun a research program on tactical C^2 teams. The overall goal of the program is to improve the effectiveness of tactical C^2 team performance. The present study addresses this measurement issue.

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The research involved three steps. First, the literature on C^2 units was reviewed, and site visits were made to two tactical and one strategic C^2 unit in order to get background on C^2 teams. The result of the first step was the selection of two tactical C^2 teams for intensive analysis. Second, personnel from these two teams were interviewed, and exercises in which the two teams participated were observed. This step was used to identify critical individual and team tasks and to determine the ways in which the teams are currently evaluated. Third, a team dimensions taxonomy that had been previously developed by the Advanced Research Resources Organization was studied as the basis for developing an assessment instrument. A prototype of the instrument was prepared. It was proposed that the team dimensions be rated using simple scales measuring occurrence, time of occurrence, and reactivity. The prototype instrument concerns one component of team performance: team functions. Other criteria of team performance discussed in the report are productivity, individual member ability, and motivation.

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SUMMARY

Objective

The purposes of this effort were to study the current assessment of team performance in tactical Command and Control (C^2) systems and to develop a prototype team assessment methodology.

Background

The Air Force uses tactical C^2 systems to task and manage theater combat missions and responses to crisis situations. While current and planned tactical C^2 systems are heavily dependent on the effective performance of teams which operate the elements of these systems, team performance has not been formally studied or recognized as critically important. As a partial response to this situation, the Air Force Human Resources Laboratory has begun a research program on tactical C^2 teams.

The overall goal of this program is to improve the effectiveness of tactical C^2 team performance. There are two aspects of this program. First is the identification of variables that influence C^2 team effectiveness. Second is the analysis of methods (including training) that can improve C^2 team effectiveness. In order to begin this program, a measure of C^2 team effectiveness is needed.

The present study addresses this measurement issue. The purposes of this project include: (a) identifying the current methods used to assess tactical C^2 team performance, (b) determining the characteristics of a method that would be most appropriate to assess C^2 team performance, and (c) developing a prototype team performance measure.

Approach

The research involved three steps. First, the literature on C^2 units was reviewed, and site visits were made to two tactical and one strategic C^2 unit in order to get background on C^2 teams. The result of the first step was the selection of two tactical C^2 teams for intensive

analysis. Second, personnel from these two teams were interviewed, and exercises in which the two teams participated were observed. This step was used to identify critical individual and team tasks and to determine the ways in which the teams are currently evaluated. Third, a team dimensions taxonomy that had been previously developed by the Advanced Research Resources Organization (ARRO) was studied as the basis for developing an assessment instrument. A prototype of the instrument was prepared, taking into consideration the characteristics of tactical C^2 teams. Future research on the instrument was also proposed, including studies needed to complete the development of the instrument, field test it, and assess its technical adequacy.

Results

Conclusions. The following conclusions can be drawn about the current evaluation of tactical C^2 teams:

- The most relevant evaluations are given during training exercises in which an evaluator provides feedback about performance.

- These evaluations are based on the expertise and experience of the evaluator, since there are no formal standards for C^2 performance.

- These evaluations focus on outcomes (e.g., number of planes downed) rather than on behavior. Team interactions are rarely explicitly evaluated.

- The assessments, during training exercises, are intentionally non-evaluative.

- There are few evaluators relative to participants, so that evaluators often are unable to provide extensive feedback to individual participants.

- Since much of the behavior during the exercise is verbal, an evaluator must be able to listen to individual conversations in order to evaluate this aspect of performance. Under exercise conditions, this type of evaluation is not feasible.

- The ultimate purpose of tactical C^2 team assessment is the determination of the readiness of these teams for war. At this point, there is no methodology that can provide this answer.

Some other conclusions can be made based on this research:

- The tactical C^2 environment is very complex and, therefore, requires complex and sensitive assessment procedures.

- Most tactical C^2 teams do not perform their C^2 function except during training exercises.

- During exercises, Air Force personnel with a wide range of tactical C^2 experience participate.

- Most training provided to tactical C^2 participants is given during and in preparation for exercises.

Development of a model of team effectiveness. As a foundation on which to develop an improved assessment method, a conceptual model of team effectiveness was prepared which includes productivity, motivation, and operational readiness. Productivity is defined in terms of the outcomes defined by Air Force experts as the purpose or objective of the team. Currently tactical C^2 teams are evaluated using these outcomes, including percent of aircraft identified within standard time limits and number of enemy aircraft destroyed. Motivation is the ability to energize behavior. Motivation is the least well-conceptualized component of team functioning; because of this, it was not a focus of analysis in this research. Operational readiness involves individual abilities and knowledges, and team coordination and maintenance. The latter component is the element of the evaluation model that was of greatest interest in this study.

Team coordination and maintenance are defined as team functions. In a previous ARRO study (Nieva, Fleishman, & Rieck, 1978) an initial taxonomy of team dimensions was prepared. In later research (Shiflett, Eisner, Price, & Schemmer, 1982), the taxonomy was revised and rating scales measuring the dimensions were developed. During observation of tactical C^2 team performance, the usefulness of the revised taxonomy was studied. It was found that all of the dimensions defined in the taxonomy could be observed. It was also determined that two additional functions need to be added: system monitoring and procedure maintenance.

Prototype assessment methodology. Although the team functions could be observed. it was concluded that the previously developed team function rating scales could not easily be used for assessing the performance of tactical C^2 teams. A possible revision was developed which includes simpler ratings of each function: occurrence, time of occurrence, and reactivity.

Recommendations. In order that the measurement device might be used for assessment, the following research needs to be conducted:

1. Further clarify the definitions of the team dimensions.

2. Develop definitions of the two new dimensions identified in the study.

3. Complete the revision of the rating scales.

4. Field-test the rating instrument to determine whether the dimensions can be observed and how easy it is to use the instrument.

5. Determine the relative importance of the different team dimensions for team effectiveness. This requires assessing the dimensions against an independent measure of team effectiveness which must be developed.

6. Using the scales to diagnose problems in the tactical C^2 teams, develop strategies to reduce these problems. This step will link the assessment instrument to the diagnosis of team problems and to the prescription of strategies for reducing the problems.

PREFACE

This effort was conducted in support of the research and development program of the Air Force Human Resources Laboratory to improve the operational readiness of Air Force command and control personnel. This program includes investigations in the following areas: (1) issues which affect team performance, (2) application of state-of-the-art computer technology to field training problems, and (3) ways to increase the effectiveness of the training provided to these personnel. One of the issues central to these research and development efforts is the ability to adequately assess the performance of the teams which perform command and control functions.

This research effort was performed by ARRO, Inc., with Dr Edwin Fleishman as Principal Investigator and Dr Merri-Ann Cooper as Project Director. It was performed for the Air Force Human Resources Laboratory, Logistics and Human Factors Division, Wright-Patterson AFB OH, under Contract F33615-81-C-0017. Contract management was provided by Mr Lawrence Finegold (AFHRL WU2313-T2-15, Techniques for Assessing the Performance of Teams).

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SECTION I

INTRODUCTION

The Air Force uses tactical Command and Control (C^2) systems to task and manage its combat missions and responses to crisis situations. Considerable resources and management attention have been focused on this area in recent years. However, while current and planned tactical C^2 systems are heavily dependent on team performance for success, team performance itself has not been formally studied or recognized as a critical element in C^2 effectiveness.

In order to address a number of significant unresolved issues in this area, the Air Force Human Resources Laboratory (AFHRL) has begun a research and development (R&D) program focusing on personnel performance and training in tactical C^2 systems. Based on their foundation research efforts, AFHRL identified a number of major R&D issues critical to the successful employment of tactical C^2 systems. These issues include: (a) team and C^2 system performance and training; (b) human resources impact on C^2 system design and operation; (c) training and aiding decision makers; and (d) team performance measures. The research described herein addresses the last of these issues, although obviously all of the issues are interrelated, and the impact of this research will be felt in all of these areas.

At the present time, the operational readiness and combat effectiveness of C^2 personnel are measured using techniques that are largely subjective and global in nature. These techniques have not been empirically shown to bear a reliable relationship to effective team performance. No team measures are available that clearly relate inadequate team performance to its causes. As a result, it is often difficult, if not impossible, to take appropriate corrective actions based on assessments of team performance. A sensitive index of team performance is necessary for maintaining optimal levels of team proficiency.

This paper describes an effort that is the first step in a research program having as its long-term objectives the identification, develop-

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ment, and implementation of effective tools to be used for the assessment of the performance of teams operating Air Force tactical C^2 systems. As the initial effort in this program, its objectives were to identify critical C^2 team tasks and to develop a prototype procedure for measuring the performance of tactical C^2 teams in carrying out critical tasks. Two C^2 teams were selected in order to accomplish the following:

1. Identify critical tasks performed by team members.

2. Identify critical team products or outcomes.

3. Identify and evaluate the methods currently used to evaluate the teams.

4. Develop a prototype of an improved assessment procedure.

5. Recommend further research to implement the procedure and to study its usefulness.

In order to explain better the purposes of this research effort, an introduction to tactical C^2 teams is presented below. Additional introductory material is in Section II, including a discussion of theory and research in the areas of team performance and effectiveness. This section concludes with the development of some basic requirements for a C^2 team assessment model. Section III describes a previous approach used for assessing C^2 team functions. Section IV includes a description of critical tasks and outcomes in two tactical C^2 teams. Section V describes and evaluates the methods currently used to assess performance in tactical C^2 teams and presents the prototype of an improved team assessment procedure. Section VI provides a discussion of theoretical and methodological issues in C^2 assessment and some recommendations for further research to implement and validate the proposed team measurement procedure.

The Nature of Tactical Command and Control (C^2) Teams

In order to plan and task Air Force tactical missions effectively, a diversity of information must be quickly gathered, analyzed, integrated and communicated to the Air Force Component Commander who can then make decisions and communicate the plans and orders to subordinate

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commanders. The tactical C^2 system plays a significant role in planning and tasking. A tactical C^2 system can be thought of as having four key elements:

1. Command authority. Provides the central authority and coordination of purpose and determines how to use available forces to accomplish mission objectives.

2. Organization. Involves the structure by which information is sent to the commander and through which plans, priorities and directives are provided to the force.

3. Communication. Provides the methods for the acquisition and transmittal of data and plans. Communication provides links between the commander and the force and between adjacent units.

4. Information. Supports the decision-making process by originating and filtering information from a number of sources. The key to the C^2 system is the effective and rapid collection, processing and transfer of information to the commander.

Training and Assessment of Performance in C^2 Systems

Currently there are a few fully-staffed operational Air Force tactical C^2 systems in Europe and in Asia. There are no such units in the United States; in this country two numbered Air Force-operated tactical C^2 units are minimally staffed. The functions of these units are primarily training rather than tactical C^2 operations. During wartime, these units will become the nucleus of expanded C^2 systems when other Air Force personnel will be added (Short & Parson, 1981).

Preparation for wartime operations of tactical C^2 systems requires effective training of the personnel who operate the peacetime tactical C^2 units and of those augmentees who will be added to the units in preparation for war. The Air Force currently trains the C^2 unit members and the potential augmentees in large- and small-scale exercises in which war conditions are simulated.

One important component of training (including the training of C^2 personnel and potential augmentees) is performance assessment. In the context of this project, performance assessment is the measurement of

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behavioral effectiveness. Performance assessment can be used in the planning, conducting, and evaluating of training. It can involve the identification of ineffective behavior and thus be used to identify training needs. During training, performance assessment can be used to monitor the appropriateness of the training process by determining whether trainees are performing the correct behaviors. After training, assessment of individual trainees' performance can be used to provide feedback. Feedback improves training by providing guidance to trainees to revise their incorrect behavior, it increases their interest in the training, and it leads to setting specific goals for performance (Bryan & Locke, 1967; Holding, 1965; Wexley & Latham, 1981). Performance assessment can also be used to evaluate training by comparing behavior before and after training.

Performance assessment. Considering the importance of training for tactical C^2 preparedness, and the importance of assessment for training effectiveness, performance assessment in tactical C^2 systems seems a useful topic of study. Performance in C^2 systems can be evaluated from three perspectives: the assessment of the performance of each participant, the performance of teams of interacting persons, and the performance of the system as a whole, including both personnel and equipment. This research focused on the assessment of team performance.

Because of the role of interaction (especially communication) between C^2 personnel, the assessment of team performance in tactical C^2 units is quite important. Tactical C^2 systems require effective communication. Centralized command is based on communication to the commander of information obtained from diverse sources. Control involves the dissemination of the commander's decisions to individuals who commit and assign aircraft and armaments to missions and targets. From this perspective, tactical C^2 systems operate using teams of interacting personnel obtaining information, sharing information, and making decisions.

The assessment of team interaction can be used, along with the evaluation of individual performance, to plan, conduct, and evaluate training. Assessment of overall C^2 systems provides additional informa-

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tion about the effectiveness of hardware, software, and other non-personnel components of C^2.

Complexity of the assessment of C^2 team performance. In order to place the findings of this effort in perspective, the difficulties involved in assessing C^2 team performance should be noted. Conducting an effective assessment requires a standard of effective performance as well as a procedure to compare observed performance to the standard. Assessment is easier if the performance is simple, observable, clearly correct or incorrect; if the situation in which the behavior occurs is not distracting; and if an observer has an adequate amount of time for observation and judgment. The assessment of tactical C^2 team performance is difficult because:

1. The assessment is of a team rather than of a single individual; thus, more behavior must be observed and evaluated.

2. Much C^2 behavior involves decision making. Such behaviors are difficult both to observe and to evaluate.

3. A significant amount of behavior in C^2 systems involves telephone communication. In order to assess communication, the evaluator must be able to listen to both sides of the communication. This procedure requires extensive amounts of time, and knowledge of C^2 operations and equipment.

4. The tactical C^2 environment is complex, involving a number of people performing a variety of actions.

5. There are no standard criteria of team performance for either tactical C^2 teams. Most standards of effectiveness are for the entire exercise. At this point, it has not been possible to trace the overall effectiveness of the exercise (in rates of enemy aircraft downed, etc.) to individual decisions, individual behaviors, or to team actions.

In conclusion, the complexity of the tactical C^2 environment, the number of persons to observe, the difficulties in observing critical behaviors, and the lack of standards for effective performance all combine to make assessment of tactical C^2 team performance difficult.

Current evaluation of tactical C^2 personnel performance. The evaluation of tactical C^2 teams and their personnel occurs primarily duri..g simulations and exercises that are conducted for the purpose of training as well as for evaluation of the readiness of the unit. During these simulations, an exercise controller or evaluator assists in the conduct of the exercise, evaluates the effectiveness of the C^2 team, and provides feedback on performance. Such feedback is often insightful, but it is subjectively based on the expertise and experience of the evaluator. Thus, although it might be quite valid feedback, it is provided in an unsystematic and unstandardized manner. In fact, there are no widely accepted standards for tactical C^2 team performance. Since the number of participants in an exercise far exceeds the number of exercise evaluators, it is very difficult for the evaluation to include a discussion of behaviors of individual participants. This may be one reason why the evaluation focuses on outcomes (e.g., number of planes downed) rather than on behaviors. In fact, almost all tactical C^2 team evaluations are based on outcomes of this type, in spite of the fact that the outcomes are often determined by many factors in addition to team effectiveness.

A typical training and evaluation scenario might go as follows. A computer-based simulation of an international emergency, lasting anywhere from 4 hours to 4 days, would be conducted either in one major unit or, on a larger scale, involving a variety of geographically separated units. At each location, a team of two or three evaluators assists in the conduct of the exercise, and provides a certain amount of feedback during the operation of the exercise in an effort to assist the team for training purposes. Such assistance is a contamination of any evaluation measures of team performance. This is not considered to be a serious problem from an operational point of view, since most evaluations are conducted purely for the purpose of assisting a team to maintain operational readiness.

Once the exercise is over, a debriefing session is held involving all the members of the exercise; feedback on unit performance, and occasionally on individual performance, is provided. The content of

these debriefings appears to be totally unstandardized, and to focus on highly visible performance decrements. These performance problems are almost always defined in terms of unit outcomes and productivity measures such as speed of identification of an aircraft, number of aircraft destroyed, and whether hostile aircraft were able to penetrate too close to a defined target area.

In general, there appears to be very little focus on individual behaviors or on the team component of the tactical C^2 system. It seems quite apparent, however, that exercise participants need to share information, coordinate, and check each other's performance, among many other team-oriented processes, in order to assure effective performance. However, this aspect of C^2 team performance appears to be considered in an unsystematic fashion, or to be completely ignored. This neglect does not stem from a lack of awareness of the relationship between internal team functioning and team productivity, but rather from the absence of a model that relates team tasks and functions to the overall team outcomes. This lack of an effective model relating individual performances, team functions, and team outcomes, is true not only of tactical C^2 teams, but of team performance theory in general.

Importance of C^2 team assessment. The availability of a method for systematically evaluating tactical C^2 team performance would be useful for a number of reasons. From a practical view, the effectiveness of training, personnel placement, and hardware innovations can be determined only if the Air Force has an objective, valid measure of C^2 personnel performance.

The need for such a measure is particularly acute in view of the fact that most tactical C^2 units are wartime units. That is, they are constituted and operational only during a state of emergency. The rest of the time they do not exist except on paper. During an emergency, these teams would be staffed by a small core of permanent cadre, and a large number of mobilization designees. Although all personnel will presumably have the proper training and background, their opportunities to practice and maintain their skills are limited, especially in the case of the mobilization designees whose full-time civilian jobs may

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have nothing to do with their C^2 function. Because an emergency situation will require a unit to come up to speed very quickly with team members who may not have an adequate amount of practice, and with little opportunity to practice their skills in a team setting before becoming operational, team level training for tactical C^2 systems becomes particularly important. Effective feedback is an essential part of this type of training.

The complex, fast-paced information transmission requirements of tactical C^2 teams require that team members not only perform their individual skills well, but also be aware of how to make the team function effectively as a team. These team functions, then, can be seen as defining internal, process-oriented, team tasks that are as much a part of the team productivity as the overall outcome-oriented measures of team performance. The development of an assessment tool that provides information and feedback on the effectiveness of team functioning will be very useful for improving training and team performance.

Section II provides a more detailed discussion on the evaluation of team performance, and introduces a conceptual model for developing a prototype evaluation methodology.

SECTION II

TEAM PERFORMANCE AND ITS EVALUATION

A brief summary of some of the team research literature is presented in this section, in order to place the current study into a meaningful context of theory and research as well as to provide a general foundation for the prototype evaluation methodology developed in this effort. Selective literature on the following topics will be reviewed: team behavior, team training, team effectiveness, communication, and assessment. More extensive reviews of these topics can be found in Here (1976), Shaw (1971), and Bass (1982).

In discussing the team research literature, a distinction must be made between a "group" and a "team." A further distinction must then be made between a tactical C^2 team and other types of teams. A group is any assemblage of individuals who are connected to one another in some way, although in much of the research literature this connection is often very tenuous. A team, on the other hand, consists of individuals who have very well-defined roles and functions and usually have a clearly defined task or product which constitutes the major purpose for the existence of the team. Laboratory groups, constituted for the convenience of the researcher, working on tasks that have nothing to do with the researcher's interests, are good examples of groups that are not teams. In recent years, researchers have become more and more concerned about the differences between such groups and task-oriented teams.

Tactical C^2 teams are similar to other teams in that they have well-defined roles and functions, and operate in a meaningful organizational context, with a well-defined task or goal. As indicated earlier, tactical C^2 teams can be thought of as having four key elements: (a) command authority, (b) organizational structure, (c) communication, and (d) information. All teams can be described in terms of whether they are similar to or different from one another on these four dimensions. However, although most teams will have an identifiable

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authority structure, as well as an organizational structure, they may not be heavily dependent on communication in order to accomplish the task, as are tactical C^2 teams. In addition, information is an essential part of all open systems, including all teams, but many teams will use the information purely for orientation and adjustment purposes. The tactical C^2 team, on the other hand, uses information as its major raw input resource, processes it within the team, and outputs it in a different form.

Tactical C^2 teams can also be compared to teams in general in terms of the basic tasks that must be performed. McGrath (1982) has categorized team tasks according to four major processes: (a) the generation of alternatives, (b) the choice among alternatives, (c) negotiation, and (d) execution. Implicit in this categorization is the assumption that most teams have a predominant process. As will be discussed in more detail later, tactical C^2 team tasks are notable in that all four processes are present to a substantial extent. In general, tactical C^2 teams are characterized by highly skilled personnel operating in a highly sophisticated, fast-paced, complex technological environment. This can result in a great deal of stress, particularly if the team is operating in a real-world emergency situation.

Team Performance and Team Characteristics

There has been a great deal of research on team characteristics and team performance. Hare (1976) cites 6,037 references on groups and teams in his review of the psychological literature on groups. A number of issues have been investigated that are relevant to team characteristics and performance in the Air Force: individual vs. group performance, group size and group effectiveness, cohesiveness and group performance, cooperation and competition in teams, communications in groups, interaction patterns in groups, individual member characteristics in the group, and leadership.

In an extensive review of the literature undertaken at the Advanced Research Resources Organization, Nieva et al. (1978) make the following substantive conclusions:

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1. In disjunctive tasks (in which group performance depends upon at least one group member performing the task well), size is positively related to performance (Anderson, 1961; Cummings, Huber, & Arendt, 1974; Goldman, 1971; Ziller, 1957).

2. In conjunctive tasks (in which group performance depends on all group members doing well), size is negatively related to performance (Frank & Anderson, 1971; Marriot, 1949).

3. The relationship between group size and performance may follow an inverted U function for certain tasks. That is to say, performance may increase as group size increases only up to a certain point, beyond which group size has a negative effect on performance (Buck, 1957; Moede, 1927; Smith & Murdock, 1970; Taylor & Faust, 1952).

4. Group cohesiveness is positively related to group performance only when group norms and standards are favorable to high levels of performance (Berkowitz, 1954, 1956; Goodacre, 1973; Grace, 1954; Martens & Peterson, 1971).

5. Intra-group cooperation, rather than competition, is positively related to group performance when the task requires high levels of interdependence among group members (Deutsch, 1949; Goldman, Stockbauer, & McAuliffe, 1977; Miller & Hamblin, 1963; Swinth & Tuggle, 1971).

6. Inter-group cooperation, rather than competition, is positively related to group performance, although the results are less consistent than those for intra-group relationships (Goldman, Stockbauer, & McAuliffe, 1977; Hammond & Goldman, 1961).

7. Communication has positive effects on the performance of problem-solving and other unstructured tasks, but has negative effects on highly structured tasks (Briggs & Naylor, 1965; Cohen, 1968; Johnston, 1966; Naylor & Briggs, 1965; Shiflett, 1972, 1973; Steiner & Dodge, 1956; Thibaut, Strickland, Mundy, & Goding, 1960).

8. Communication that is task-related improves performance, but non-task-related communication impairs performance (Federman & Siegel, 1965; Johnston, 1966). (The distinction, however, may be difficult to make in real life.)

9. Homogeneity in personality and attitudes appears to have favorable effects on team performance on relatively structured non-cognitive tasks, whereas heterogeneity appears to have favorable effects on unstructured, prob-

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lem-solving tasks. However, the effects of homogeneity and heterogeneity also depend on the particular dimension of personality or ability on which homogeneity or heterogeneity is measured (Altman & Haythorn, 1967; Hewett, O'Brien, & Hornik, 1974; Hoffman & Maier, 1961; Shalinsky, 1969; Schultz, 1955).

10. Groups that are heterogeneous in ability appear to perform better than homogeneous groups on cognitive tasks, when the average ability level in the group is controlled (Hill, 1975; Hoffman & Maier, 1961; Tuckman, 1967).

11. Egalitarian distribution of power tends to be positively related to performance. However, the relationship appears to be complex and is affected by personality, task, motivation, and reinforcement variables (Bass, 1963; Rosenbaum & Rosenbaum, 1971).

The following additional conclusions were drawn from research areas outside consideration of the Nieva, Fleishman, and Rieck (1978) review:

1. Pairs of individuals and larger groups are usually more efficient and productive than are individuals in solving problems. The superiority is especially evident when division of labor is possible, and when task performance may be aided by checking. Although group performance is usually better than that of the average group member, group performance is seldom better than that of the best individual on the team. Hare (1976) concludes that group superiority may, therefore, result from the presence of superior individuals in the group (Anderson, 1961; Beasley, 1958; Daval, 1967; Goldman, McGlynn, & Toledo, 1967; Lorge, Tuckman, Aikman, Spiegel, & Moss, 1955a, 1955b; Luchins & Luchins, 1961; Marquart, 1955; Schoner, Rose, & Hoyt, 1974; South, 1927; Steiner & Rajaratnam, 1961; Vine & Davis, 1968; Zajonc, 1962; Ziller, 1957).

2. When problem-solving discussion meetings are observed over a period of time, certain activity trends may be noted. The group first collects information, then evaluates it, and finally presses for a decision (Bales, 1952; Bales & Strodtbeck, 1951; Landsberger, 1955; Plank, 1951).

3. Although a great deal has been learned about the functions of leaders in groups, leadership styles, and situational determinants of leadership, those characteristics and behaviors of leaders which result in subordinate satisfaction and team effectiveness have not been fully determined (Bales & Slater, 1955; Eagly, 1970; Fleishman, 1973; Gibb, 1969; Hare, 1976; Jaffee, 1968; Korman, 1966;

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Korten, 1962; Lewin, Lippitt, & White, 1939; Porter, Lawler, & Hackman, 1975; Sales, 1966; Shaw & Blum, 1966; Stogdill, 1950).

4. When turnover is moderate and does not involve crucial personnel, the effects of changes in team membership are not important (Forgays & Levy, 1957; Trow, 1964).

5. Fifty percent of team performance variance is accounted for by individual team member contributions (Comrey, 1953; Havron & McGrath, 1961; Rohde, 1958).

6. In normal operations, flexibility of operating procedures increases group performance. Under stressful conditions, the availability of different alternative behaviors reduces team effectiveness (Alexander & Cooperband, 1964; Howell, Cristy, & Kinkade, 1959; Kidd & Hooper, 1959).

7. Interaction between individuals working on monitoring tasks reduces performance (Briggs & Johnston, 1967; Briggs & Naylor, 1964; Roby & Lanzetta, 1956, 1957). In contrast, interaction often improves group performance on problem-solving tasks ((Levine & Katzell, 1971; Thibaut et al., 1960).

8. Stress produced by information characteristics (load) relates to performance of teams in task settings in curvilinear fashion. While some stress is beneficial, both absence of stress and excessive stress produce negative effects for cohesion and performance (cf. the summary provided by Streufert & Streufert, 1978).

9. Environmental effects on team/task performance have been demonstrated by some researchers (e.g., Baum & Epstein, 1978). Whether or not the environment does affect performance depends on task variables as well (cf. Streufert & Nogami, 1979). Crowding has detrimental effects, particularly when stress (e.g., combat) in restricted space (e.g., tank crews) occurs during tasks requiring continuous attention and team interaction.

This literature indicates that there is no consistent relationship between certain variables (e.g., size, cooperation, communication, and power distribution) and group performance. Given these results, the assessment of tactical C^2 team performance must consider a wide range of variables, including the task, group size, communication, member ability, and operating procedures.

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Team Training

An area of research especially relevant to this effort is team training. The early work in team training has been summarized by Briggs and Johnston (1967) and Glanzer (1962). More recently, authors have been pointing to serious problems of technology underdevelopment in team training (Denson, 1981; Hall & Rizzo, 1975; Wagner, Hibbits, Rosenblatt, & Schultz, 1967). Denson (1981) points out a major theoretical limitation in team training studies. He concludes that team training researchers have made little progress in identifying the behaviors and skills that lead to more effective team performance. Failure to use available educational and training technology, as well as failure to resolve fundamental issues relating to team concepts and team performance, has relegated team training to a state of questionable effectiveness.

In a recent review of team training, Meister (1976) offers the following conclusions:

1. Individual training is superior to team training for simple or only moderately complex tasks; team training appears to be relatively ineffective in producing performance beyond that resulting from individual operator training.

2. High fidelity training conditions are important determiners of operational task performance where fidelity refers to equipment, procedures, or skill requirements; input fidelity is more crucial than output fidelity.

3. Given incompatible criteria of system performance such as speed and accuracy, teams will emphasize that aspect of performance about which they receive knowledge of results.

4. Team training, like individual training, is affected by task complexity. Training is, of course, easier and performance superior on less complex tasks. Task organization in team training is a less significant variable than task complexity.

The Defense Science Board (1976), in a review of training in the military, made two conclusions about R&D work on team training. The first conclusion was that there had not been very much research carried

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out on the topic, considering the amount of team training in the three military services and the amount of research on individual training. The second conclusion was that much of the team training R&D was mission-oriented and involved developing specific training courses and team training devices (Havron, Burdick, Hutchins, & Backlick, 1954; Havron, Lybrand, & Cohen, 1944; Jensen, Tilton, & Anderson, 1958, Tremble, 1978).

Some studies on team training in the military are less specific to training a unit for a specific task. A number of studies in this category concern the application of principles derived from individual training to team training, including research on the similarity between the training situation and the performance situation (Alexander & Cooperband, 1965; Briggs & Johnston, 1966; Briggs & Naylor, 1965), knowledge of results (Cockrell & Sadacca, 1971; Short, Catlon, & Klaus, 1968), and task complexity (Naylor & Briggs, 1965).

There are also some studies dealing with more basic questions about team training, including research on the relative effectiveness of team and individual training (Briggs & Johnston, 1965; Kanarick, Alden, & Daniels, 1971; Klaus & Glaser, 1960, 1965, 1968), the type of team skills and team performances that might be improved with training (Alexander & Cooperband, 1965; Federman & Siegel, 1965; Sidorsky & Houseman, 1966), when to use team training (Alexander & Cooperband, 1965; Kanarick et al., 1971), and the evaluation of team training, including work on the Army Training and Evaluation Program (ARTEP) exercise and the Army's recently developed laser signal-based Realistic Training Program (REALTRAIN).

The research on team training points to a central issue which the present effort must address. As Denson (1981) states, team training rests on the assumption that team output is something more than the sum of individual outputs and that certain team characteristics and processes determine team effectiveness. He concludes that these unique elements should be the focus of team training. However, the team training literature has not proven illuminating concerning the identification or measurement of these team elements. It is necessary, in the present effort, to begin to analyze these team variables.

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Team Effectiveness

Several techniques have focused on teams as a way to improve organizational functioning. For example, psychologists involved in the socio-technical systems approach, job redesign and job enlargement (cf. Hackman, 1975; Thorsrud, Sorensen, & Gustavsen, 1976; Walton, 1975) have often used teams in their attempts to revise the technical and social aspects of jobs. These researchers and consultants attempt to increase satisfaction and productivity by building in greater variety, discretion, feedback, identity, and responsibility in jobs (Friedlander & Brown, 1974). One method frequently used to improve jobs is to revise the way work is allocated. Rather than having segmented work roles, teams are developed. The team is given greater responsibility over its work, and may control hiring, quality inspection, and certain management functions (Walton, 1975). In this approach, the team becomes the means through which individual jobs become enlarged and enriched.

Team building (Dyer, 1977), in contrast, is a technique for improving the effectiveness of existing work groups. Team development is a general label for all the intervention strategies focusing on improving the group's ability to analyze and solve the problems interfering with its functioning, and may focus on establishing clear goals, improving the quality of interaction among team members, and increasing clarity about each member's role and responsibilities.

Survey feedback is a collaborative effort between a consultant and organizational members to gather data about organizational processes, analyze the data, interpret the data and plan techniques for change (Beer, 1976). An important component of this process is the team meeting to discuss the data. Such meetings between work group members have been found to increase satisfaction with the feedback process and use of the information gained (Klein, Kraut, & Wolfson, 1971).

Laboratory training uses groups as a means to increase self-examination, experimentation, and sensitivity to the behavior of others. Originally laboratory training was carried out with groups of

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strangers. More recently, the technique has been used with work groups so as to increase use of the new skills both at work and to focus on group processes that promote team effectiveness (Buchanan, 1969; Morton & Wright, 1964).

In general, organizational effectiveness efforts are practitioner-oriented and directly concerned with changing the organizations (Campbell, 1973). Much of the research concerns changes that have resulted from specific interventions (e.g., Campbell & Dunnette, 1968; Nieva & Myers, 1979; Sherwood, 1971). The studies show that organizational interventions, including those focusing on teams, can change organizational functioning. However, research on the most appropriate techniques for handling specific problems and working in different types of organizations has not yet been extensively carried out (Burke, 1977).

The evaluation of team effectiveness is a complex issue. A number of basic questions on this issue remain unresolved. There is still substantial disagreement about the appropriate criteria of effectiveness to use (Campbell, 1977) and the nature of the characteristics and processes of teams as distinct from the characteristics and processes of individual team members (Nieva, Fleishman, & Rieck, 1978).

The team effectiveness literature reflects a field that is primarily pragmatic rather than research-oriented. The assessment tools that have been developed by these psychologists depend primarily on the knowledge and skill of the assessor. Since lack of standardization is a major problem with the current assessment of tactical C^2 units, the team effectiveness literature will not provide much assistance concerning the improvement of C^2 assessment.

The literature may provide some insights concerning the use of assessment results for team improvement. For example, Golembiewski and Hilles (1979) describe the strategy for translating the results of a survey into action. The procedures they cover include explaining survey results, action planning, implementation of change, and evaluation of results.

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Communication

Communication is a critical feature of the tactical C^2 system and its component teams. Communication is the means by which information is exchanged. In order for the tactical C^2 system to plan and manage combat effectively, information must be exchanged efficiently and decisions must be transmitted quickly; both of these processes involve communication. Any instrument that evaluates tactical C^2 teams must assess the communication among team members. The extensive literature or communication in groups can provide background for the development of this aspect of the assessment instrument.

Communication is defined as verbal interaction among team members, which may vary in amount or in type. Amount of communication is a simple indicator of quantity, whereas type of communication refers to the mode or content of communication.

Amount of communication. Research on the effects of amount of communication on group performance generally irvolves two types of tasks: problem-solving tasks typically found in small group research, and vigilance-monitoring tasks.

Many studies show an overall positive relationship between communication and performance on a range of problem-solving tasks when the performance measures used are quantity or quality. Shiflett (1972, 1973) compared groups that were allowed to interact to groups that were not allowed to communicate in a crossword puzzle task, and concluded that there was a positive relationship between number of words solved and communication between members.

Amount of communication had no relationship with performance, however, when time measures of performance were used. Levine and Katzell (1971) showed positive relationships, using a quantity or quality indicator of performance, but found no effects when time measures were used. It appears, therefore, that in problem-solving tasks intra-group communication does not slow down the solution process as one might expect. Instead, communication within the group allows a better quality solution to be generated with no apparent cost in time.

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While communication appears to have positive effects on problem-solving tasks, the opposite was generally found among vigilance-monitoring studies. In these studies, subjects were asked to monitor a screen and respond to certain patterns. These studies, which emerge from team training literature, show negative relationships between amount of communication and performance (Briggs & Naylor, 1965; Johnston, 1966; Naylor & Briggs, 1965).

Task effects and amount of communication. The preceding discussion shows that relationships between amount of communication and group performance were affected by the task type (problem-solving vs. monitoring) as well as by the performance measure employed (quantity and quality vs. time). In addition, it appears that amount of structure in a task may account for some of the differences in the results obtained by the studies. The problem-solving tasks which showed positive relationships between amount of communication and group performance are characterized by a relatively low degree of structure, compared with the monitoring tasks which were highly structured and showed negative communication-performance relationships. Several studies support this hypothesis. Steiner and Dodge (1956) found that communication improved performance in unstructured tasks but communication had no effect on structured tasks. Also, Thibaut et al. (1960) found that intra-group communication is especially critical with unstable task demand; the concept of stability is closely related to structure.

One likely explanation for the moderating effects of task structure on the communication-performance relationship is that tasks which have low structure require more planning and coordinative efforts than do tasks which have clear requirements. Communication in unstructured situations, therefore, is likely to be necessary to achieve task success, whereas communication in already structured situations would be superfluous to task interests. In support of this argument, Johnston (1966), who found generally negative communication-performance relationships, also found that non-task-related communications impaired performance. Similar results were reported by Federman and Siegel (1965). On the positive side, Shure, Rogers, Larson, and Tassone (1962) reported

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that when groups were given an opportunity to plan their strategy on an unstructured task, they performed better than groups not given this opportunity.

Content of communication. Very few studies have investigated the effects of types of communication within a group on group performance. As previously noted, Federman and Siegel (1965) and Johnston (1966) found that non-task-related communication retarded performance. Federman and Siegel (1965) investigated the different messages in communication and correlated them with productivity in a helicopter team submarine-tracking task. They found a positive relationship between performance and increases in (a) activity (process) messages, (b) evaluative messages, (c) phenomenological ("what we'll be doing") messages, and (d) requests for information messages. Overall they found a positive relationship between performance and information, opinion messages, and thinking messages, and a negative relationship between risk-taking messages and performance.

Patterns of communication. Standard communication nets refer to the pattern of communication within the group that is permitted by the investigator. Although many forms of networks have been used by various researchers, the most frequently used networks include the circle (in which each member can communicate only with the member on his/her right or left), the wheel (where each member communicates to a centralized person), and the all-channel network (where each member can communicate with every other group member). Typically, the studies used the common symbol problem developed by Leavitt (1951). In this task, each member received a different card containing several symbols, and the task was to find the symbol common to all the cards received. Over half of the studies used the common symbol task, although other problem-solving tasks (e.g., business games and math problems) were also used.

Research about communication networks, mostly conducted in the 1950s and early 1960s, has declined in popularity in recent times. Several extensive reviews have been written (Collins & Raven, 1968; Glanzer & Glaser, 1961; Shaw, 1964) about communication networks, and the reader is referred to these for more information. The studies

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discussed here are by no means an exhaustive compilation of the studies conducted in the area, but are representative of the major trends in the area.

Many studies indicate that groups with all-channel communication networks have better performance than do groups with wheel communication networks. For example, Snaw (1958) found that groups with two-way communication (a form of all-channel network) performed better than groups with centralized wheel structures in problem-solving tasks. This finding was replicated by Lawson (1965) using mathematical problems. Groups with wheel networks, in turn, tend to perform better than groups with circle communication networks. For example, Leavitt (1951) found fewer errors in the performance of groups with wheel networks than of groups with circle networks. Morrissette, Switzer, and Crannell (1965) and Morrissette (1966) also found that performance by groups using the wheel network had fewer errors and was faster than performance by groups using the circle network.

Findings contrary to these general trends, however, have also been reported by varous studies. For example, Christie (1954) reported that groups in the circle network were able to reconstruct number lists better than the all-channel network group. Likewise, Christie, Luce, and Macy (1952) reported that the circle was more accurate than the wheel or chain networks in a common symbol problem. Other studies (e.g., Shaw, 1954) have reported no effects on performance attributable to communication nets.

Although a small set of relationships has emerged in a fairly stable and reliable manner, the results of much of the communication net research are ambiguous and inconsistent. Findings appear to be extremely specific to the particular experimental situation involved. In addition, the effects of communication networks seem to be affected by a number of variables such as organization, task difficulty and type of problem.

Because of the importance of information within the tactical C^2 team, communication assumes a major role. The communication network is

a simplified model of interaction and thus cannot be applied directly to studying tactical C^2 team interactions. However, this literature indicates that the pattern of interactions must be examined in order to understand decision making in these teams.

The Assessment of Team Performance

A great deal of research has been conducted using small groups of college students assembled for the purpose of studying team characteristics. Such groups usually met for brief periods and performed tasks that were simple (e.g., math problems, puzzles, writing essays), since specialized training was not feasible. Under these conditions, team performance was easily evaluated, either in terms of the number of products produced, the number of correct solutions, or the speed of task performance (see Bass, 1982, for a review of this literature). Because of the simplicity of the tasks, assessment of group performance was obvious, easy, and of little relevance to assessing real, rather than experimentally created, groups.

Researchers who studied existing groups or groups in training were faced with evaluating performance of more complex tasks. Under these conditions, the assessment of team performance has become more difficult and more useful. However, it is not a well-conceptualized topic. As Denson (1981, pp. 28-29) noted, "The team performance measurement area is not yet well defined and to some extent reflects the ambiguities associated with the definition of the team itself, team behaviors, and team functions."

One of the simplest team assessment approaches used has involved general ratings of team performance, often in terms of the quality of the team's product or the effectiveness of its performance (e.g., Bass, Farrow, & Valenzi, 1979). A major problem with this approach is that the goals of the team and the nature of its task are not adequately considered in the evaluation.

Measures of performance of the system or the entire operating unit, in contrast, do assess the degree to which specific team goals are met

(Obermayer, Vreuls, Muckler, & Conway, 1974; Turner & Bard, 1972; Zophy, 1975). For example, Turner and Bard (1972) begin their discussion of Airborne Warning and Control System (AWACs) assessment by describing the major functions of the AWACs: reaction time (reduction in time to receive and process information), command, surveillance, control, and communications. The assessment of AWACs is based on how effectively these functions are carried out. For example, the following are used to evaluate the ability of AWACs to control friendly tactical aircraft: the number and percent of friendly aircraft under operational control per unit time, and the number and percent of tracks passed to ground-based C^2 elements.

Although the assessment of system performance is an advancement over the global assessment of team performance, often this approach does not differentiate among the contribution of individual team member factors, team factors, and the influence of equipment. For example, Obermayer et al. (1974) identified types of flight maneuvers. Each phase was separately assessed. Precise and objective criteria were derived. However, using this elaborate, well-planned and highly auto-mated approach, it is not easy to differentiate causes of problems: 'ndividual pilot error, ineffective crew interaction or aircraft failure (although the latter could be determined at a later time).

Some researchers have made special attempts to differentiate and independently assess individual and team performance (Kaplan & Barber, 1979; Turney & Cohen, 1931). Turney and Cohen (1981), in an investigation of Navy team training activities, prepared a list of five team tasks which were assessed separately from individual tasks. The team tasks were transfer of information, timing, adequacy of communication of information, leadership, and coordination.

A second major advance in the team assessment literature is the improvement of the assessment format. A great deal of team assessment uses general ratings of team characteristics (e.g., Bass et al., 1979). The ratings are often vague, and little guidance is provided as to how to assign ratings. One example of a procedure used to improve this form of assessment was developed by Barber and Solick (1980).

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Their assessment instrument was a task rating scale which included observable events to allow the evaluator to judge whether a behavior did or did not occur.

Recent Research on Teams

A careful scrutiny of the publication dates of the above cited research on teams, as well as the many uncited sources upon which a number of the summary statements are based, would indicate that the vast majority of the research occurred before 1970. Even more noteworthy is the fact that research on task-oriented teams (in contrast to laboratory groups) has been very scarce since the late 1950's, when the military sponsored a substantial amount of the work in this area. Although some of that research made its way into the open literature, a large amount was reported in technical reports that were not widely distributed.

Team productivity. The lack of research on task-oriented teams during the past 20 years does not mean there was a lack of interest in team tasks, team process, and team effectiveness. Attempts have been made to relate the type of task to team productivity, as well as attempting to relate various internal group processes to team productivity. Work by Hackman and Morris (1975) represents an excellent example of substantial advances in the categorizing and understanding of team tasks and team processes. Using their work as a foundation, McGrath (1982) more recently has developed a model of team tasks in which tasks are organized according to their similarity or dissimilarity along four critical process dimensions. Also during the late 1960's and early 1970s, work by Laughlin and his associates (Laughlin & Branch, 1972; Laughlin, Branch, & Johnson, 1969) studied the compositional effects of team skills on team productivity, while Shiflett (1973) studied the effects of division of labor on team productivity. A substantial amount of work has been done on the decision-making process in group contexts, and the work of Davis and his associates (see Davis, 1973), particularly as these processes apply to juries, is noteworthy.

Also during this period, there were a number of advances in the understanding of how individual inputs contributed to the overall team

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product. Steiner (1972) first brought together a number of different models of team productivity, each reflecting different task characteristics, which in turn affected the contributions of the individual members. Shiflett (1979b), building on Steiner's approach, showed that all of those models were really variations on a general model of productivity if internal task and organizational structures were considered to have a weighting effect on individual contributions. Recently, O'Brien (1982) has suggested that structural role theory represents a useful theoretical basis for estimating those weights.

McGrath model. Very little of the research and theory on teams has focused on task-oriented teams that exist for extended periods of time in which team members get to know each other well. An example of one theoretical approach to these teams is McGrath's (1982) task circumplex model which attempts to show that various task types are systematically related to each other when they are plotted in a two-dimensional quadrant space (a circumplex). Each quadrant reflects one of four basic processes: to generate alternatives, to choose alternatives, to negotiate, and to execute. In the quadrant reflecting the generation of alternatives there are planning tasks and creative tasks, whereas in the quadrant reflecting choice among alternatives there are what he called problem-solving tasks and decision-making tasks. In the negotiation quadrant are conflict resolution tasks, mixed motives, and other conflict-type tasks. Finally, in the execute quadrant are performance and psychomotor tasks, along with contests, battles and other competitive tasks. To assess the utility of McGrath's model in understanding tactical C^2 tasks, it is necessary first to locate a C^2 task in the two-dimensional "circumplex" space. It is immediately apparent that C^2 tasks contain components of virtually every process. Planning is an essential part of the task, particularly in allocating resources Decision making would be recognized as critical; however, the C^2 task is also clearly an execution task since there is no doubt that C^2 tasks involve battles or competitive situations. Physical resources are indeed being moved around, and a successful team will presumably have some left over at the end of the battle. Thus, although

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McGrath's conceptual model is a particularly useful step forward in the understanding of processes in team tasks, it is quite clear that some, if not many, categories of tasks that exist in the real world are not easily reflected in his model because they tend to be substantially more complex than the typical single process found in most laboratory research.

Team training. Much of the Army's recent research on teams has concerned training. In particular, training scenarios and evaluation techniques have been developed for infantry squads and tank crews. Their focus has been on developing realistic simulations utilizing laser signals from rifles and guns to indicate hits. Under the rubric REALTRAIN, several highly motivational simulations have been developed and are now used with some regularity in the Army (Wagner et al., 1977).

Hackman's research program. One of the few major team research programs now underway is that of Hackman (1982). His strategy is to develop an observation and interview questionnaire that will obtain as rich, diversifie , and complete data as possible on each team observed. Develo nt of the instrument, which he clearly defines as prototypical and unvalidated, has taken over a year and the data collection itself has been continuing for another year. After nearly 3 years of work on the project, Hackman still felt that he did not have enough data to perform proper statistical analyses for validating and revising the questionnaire.

Of particular interest in his research program is his insistence on narrowing the domain of observable groups to those which met three criteria: (a) they must be real, in the sense that they are perceived so by members and that members are significantly interdependent and have differentiated roles; (b) they must have a task to perform, thereby eliminating most social groups and clinical, counseling, and sensitivity groups; and (c) teams under observation must operate in an organizational context, thereby eliminating most of the laboratory research on teams. It appears that another 2 or 3 years will be necessary before meaningful findings will begin appearing. Although it is a broadly

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focused basic research program investigating many different aspects of team functioning, the program includes a major component of performance evaluation in order to establish criteria against which to validate the many research questions to be addressed.

ARRO's taxonomic research. Another important research program currently underway is being performed by ARRO, focusing on development of a taxonomy of team functions. This work is a part of that general research program initially funded by the Army. The program began with a major review of the literature, reported in Nieva, Fleishman, and Rieck (1978). That report attempted to integrate a diverse and disorganized literature on team functions into the first theoretically based taxonomy. There had been no integrative attempt of this type in the prior literature, and the vast majority of the literature reviewed by Nieva et al. was, in fact, not very useful and was not reflected in the final development of the taxonomy. Much of the background research that was applicable to developing the taxonomy came from the training literature.

The second step in that program was to take the taxonomy and attempt to apply it in a real-life Army setting. This involved observing Army teams in training settings, and developing instruments designed to assess the extent to which various functions occurred. This particular project is described in more detail later in this paper, in conjunction with the description of the evaluation model.

Implications of Prior Research for C^2 Team Evaluation

In spite of many years of research on the relationship between team performance and other factors in the team setting, only a handful of relationships have been well established. It is only recently that attempts to conceptualize systematically the relationships between team effectiveness and other variables have begun to emerge with any promise of shedding light on the processes involved.

When trying to decide on how to evaluate tactical C^2 team effectiveness, this lack of clearly established relationships between team

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characteristics and productivity or output becomes quite a serious stumbling block. Standard productivity measures of tactical C^2 teams have at least two drawbacks. First, performance is often a function of output measures that can only roughly be linked to the behaviors of any team or individual. Second, true performance measures can be obtained only during actual combat situations. Consequently, alternative measures are obtained in training simulations and exercises which lack certain elements of the reality of a true combat situation, especially the high level of anxiety and stress that would accompany a real emergency situation. For these reasons, performance measures, while having some usefulness, are generally considered to be suspect in evaluating tactical C^2 team effectiveness.

Operational readiness may be more useful in understanding team effectiveness. Operational readiness is defined as the sum of individual member ability and effective team interaction. However, the term is not well-conceptualized or adequately measured.

From a training perspective, operational readiness is likely to be a major concern, with attention focusing on the development of a high level of individual, task-related skills. However, the relationship between individual abilities and team productivity is moderated by various team processes ("throughputs" in some systems terminology). The authors contend that these team processes or functions are the major component of operational readiness and constitute a proper concern for team training and team evaluation. The evaluation model and methodology to be developed in the next section is based on this premise.

SECTION III

PRELIMINARY C^2 TEAM PERFORMANCE EVALUATION MODEL

In developing a model for assessing and evaluating team effectiveness, it is first necessary to determine what team performance criteria form the basis of the evaluation. This statement reflects a major problem not well dealt with in the team research literature. There is no consistent agreement in the literature as to what does or does not constitute team effectiveness (Hackman, 1982). Ultimately, of course, the formally defined goal of the team is its product and, consequently, a measure of its effectiveness. There are, however, two drawbacks to relying on this criterion alone as the formal measure of team effectiveness. First, the team product is determined by a number of factors that are often beyond the control of the team; for example, any environmental or contextual factors which either hinder or help the team will influence productivity. Availability of resources, quality of equipment, and innumerable other factors can influence productivity. Second, there are a number of other things which teams do and/or produce that could be seen as intermediate productivity outputs which also may have a strong impact on the final output. Failure to consider these intermediate outputs can result in little or no real understanding of how teams perform.

In the present effort, the approach to evaluating and assessing C^2 teams will consider several components of effectiveness. Effectiveness involves not only final productivity outputs but also intermediate processes and products. The need for multiple criteria of team effectiveness is apparent in view of the inappropriate productivity criteria typically available on C^2 teams, and because of the short life span of many Air Force tactical C^2 teams. Inappropriate productivity criteria result from the fact that outcomes are often dependent on many factors external to the team and not under its control, as well as from the fact that most performance evaluations are based on simulations and exercises that provide at best moderate approximations of genuine

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wartime scenarios. The short-lived nature of Air Force tactical C^2 teams stems from the fact that they are formed and staffed only during emergency situations or for training purposes. This means that there will be no opportunity to gain effectiveness information on teams with a history and/or an expectation of continuing as a team into the future. It also means that the C^2 staffing will consist primarily of mobilization designees or other staff personnel whose primary work has little or nothing to do with their tactical C^2 functions. Thus, these newly formed teams will be staffed by personnel who, although trained for their roles by the Air Force, will have had few opportunities to practice their skills, and almost no opportunity to work together with the other individuals in the unit, as a team.

For these reasons, the authors propose a three-fold criterion of team performance consisting of productivity, operational readiness, and motivation. This approach stems from a model proposed by Stogdill (1959). He suggested that a group or team is an open interaction system in which actions determine the structure of the system, and successive interactions have effects on the identity of the system. Team structure is used here in its broadest sense, to include personnel and physical equipment in addition to roles and communication channels. This process will be much more apparent in emergent tactical C^2 teams than in proceduralized teams, but the process is assumed to be always operating in any team situation. In this context, then, the basic definition of a team function is any action that creates, maintains, or changes the team structure.

Stogdill argued that there are three essential elements of team productivity or, as he called it, team achievement: productivity, morale, and integration. Stogdill defined productivity as the degree of change in expectancy values created by group operations, but for purposes of the present effort it will be defined simply as the formally defined output or purpose of the team. Morale was defined by Stogdill as freedom from restraint in action toward the goal. Stogdill's third element of team achievement was integration, the extent to which team structure and operations are maintainable under stress. As Stogdill

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used it, integration is a rather complex concept related to socio-emotional processes and to his suggested operational definition of group cohesion. For purposes of the present effort, the approach to the concept of integration was simpler and less tied to socio-emotional processes.

Three Criteria of Tactical C^2 Team Effectiveness

By modifying Stogdill's (1959) terms and definitions, to fit somewhat better a tactical C^2 setting, the authors propose a model of team achievement that consists of three criterion categories: productivity, motivation, and operational readiness. Each of the criteria represents team responsibilities or goals which must be attended to in order for a team to be successful.

Productivity is defined in terms of those outcomes defined by Air Force experts as the purpose or objective of the team. Typical measures of this criterion include percent of unidentified aircraft identified within standard time limits, number of enemy aircraft destroyed, maximum airspace penetration, etc. All of these reflect the ultimate productivity criterion: winning the battle. They are the primary measures of C^2 effectiveness used by the Air Force. The existing productivity definitions developed by Air Force command and training experts are reasonable definitions of outcomes. However, they are global and provide no assessment of either individual or team performance.

Motivation has been substituted here for Stogdill's morale concept, since motivation is currently used more frequently to describe the ability to energize individual behavior. Broadly speaking, anything which causes behavior can be thought of as a motivation, but here an attempt was made to restrict the list of motivators to those under the control of C^2 command and staff personnel. Motivation is an essential team function that must be performed by appropriate personnel in order to develop and maintain effective teams.

Operational readiness describes the state of the team's physical and personnel resources and the ability of team members to act in a

coordinated, integrated way. Machine readiness criteria are well defined, and many precise physical measures of readiness have been developed over the years by Air Force engineers. Personnel resources include skills, knowledge, and ability. The operations and training C^2 staff are reasonably knowledgeable about the required skills, knowledges, and abilities. Despite this understanding, prediction of performance is difficult since personnel can be expected to show variability in the use of their skills from day to day as a function of their physical, emotional and mental well-being.

Team readiness represents individual ability and the ability of individuals to perform together as a team. This ability comes from at least two sources: (a) the system procedures imposed by equipment and standard operating procedures, and (b) the ability of individuals to recognize what they are supposed to do and when they are supposed to do it without any instruction. This ability comes about through training together as a team. In even the most highly proceduralized of settings, this individual ability is essential; otherwise, timing and action errors inevitably occur.

The essence of a smoothly functioning team, then, involves effective coordination of the activities of individual team members and the ability to maintain such coordination over time. These are all skills that can be defined as team functions. Effective team leaders or team members will recognize that a part of their tasks includes maintaining an effectively functioning team as well as performing their individual tasks.

The authors have decided to begin the development of a comprehensive C^2 assessment methodology by analyzing one component of team effectiveness: team functions. Although team functions are only one aspect of team effectiveness, it is reasonable to begin the development of a comprehensive measure of team effectiveness by assessing this component. Although they are not well-understood within the context of tactical C^2 teams, there is an extensive literature on teams that can be used as a basis for conceptualizing team functions. Understanding team functions should prove most useful for understanding and ameliorating

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problems in tactical C^2 teams and for recommending procedural and
training remedies. The analysis of productivity indicates only problems
and not problem causes. Analysis of team functions allows the assessor
to understand the internal process that results in outcomes; analysis at
this level should be more useful for understanding the problems and
recommending changes.

This focus on team functions does not mean to discount the
importance of the other elements of team effectiveness. They will be
integrated into the assessment picture in Section V, following a
description of the results of site visits made to observe operational C^2
teams.

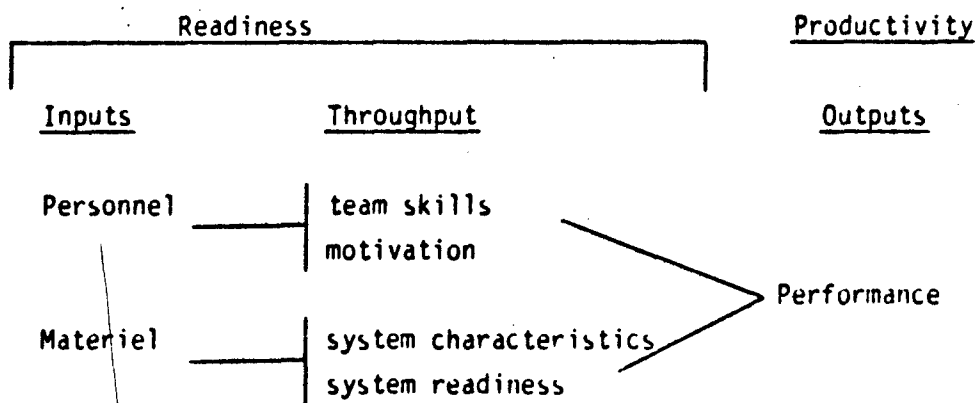In summary form, the team effectiveness model can be illustrated as
shown in Figure 1:

Figure 1. The team effectiveness model.

Team Functions

Since the authors have decided to focus the tactical C^2 assessment on team functions, it is essential to identify, define, and categorize these functions. The initial work of studying team functions was undertaken at ARRO by Nieva, Fleishman, and Rieck (1978). They reviewed a substantial amount of literature with the goal of identifying performance dimensions that made effective, synchronized work possible. Much of their research focused on the team training literature and is described in detail in their report. The result of their effort was the development of a provisional taxonomy of team performance.

Those authors also attempted to clarify the level at which the team dimensions or functions should be categorized. That is, how broadly or narrowly should each function be defined? This involved distinguishing between so-called "team-level" functions and the more specific tasks or sub-functions characteristic of nearly any open system. One problem is the fact that the terms "function," "task," and "process" are often used interchangeably in the human engineering literature. A further problem lies in the intended application. For example, training and evaluation needs may dictate use of a substantially different set of functions than those useful for a broadly based research project.

In order to avoid defining functions so narrowly that they become inseparable from specific tasks, the research attempted to define functions broadly enough that the function involves a series of qualitatively different tasks or sub-functions. For example, in an open system, a complete transaction involves the input of information and energy, the processing of the information, an action or implementation phase, and a monitoring or feedback phase which results in the action being terminated, maintained, or modified in some way.

All team-level functions were seen as potentially containing these four elements: input, process, output, and feedback. Implicitly or explicitly, the occurrence of a team-level function means that all of these four processes have occurred, whether or not they can be directly observed.

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Team functions, then, serve to create and maintain a system in which resources represented in personnel and equipment are organized to match a specific task or mission. They are, in effect, recurring mini-organizational processes which occur in both a planning phase and an implementation phase. Additional uses of the functions include altering the organization of the team while it is in the process of accomplishing its task, in order to adapt to situations as they occur. Motivational functions act to vary the degree of "energy" available to the team. A team operates with a particular set of resources, but the actual amount of work that can be accomplished is also a function of the motivation of team members.

In a follow-up project at ARRO, Shiflett, Eisner, Price, and Schemmer (1982) undertook to test the usefulness of the provisional taxonomy developed by Nieva, Fleishman, and Rieck (1978) by observing Army combat and combat support teams. Shiflett et al. made a number of modifications to the taxonomy based on their observations, so as to increase the consistency and breadth of the conceptual system underlying the original taxonomy. The researchers were especially sensitive to events and activities that did not seem to fit well into the then existing categories. In addition, early experiences in trying to use the taxonomy provided insights into its structure that initially were not well elaborated. For example, it was apparent that a number of processes could serve a general function, and that there is clearly more than one way to organize a function taxonomy.

One of the first steps taken in revision was eliminating the organizational scheme used in the provisional taxonomy. Functions were originally organized into four categories: team orientation, team organization, team adaptation, and team motivation. The primary problem with this particular organization of functions was that many of the functions classified as organizational in nature could also be seen as serving adaptation functions, and vice versa. In other words, functions were defined in the provisional taxonomy such that specific functions could fit into more than one functional category. To eliminate this problem, the functions were revised into the following categories: team

orientation, resource distribution, timing, response coordination, and motivation.

By recognizing the existence of task phases, it is possible to create a taxonomy in which a relatively small number of team functions are seen as likely to occur in all phases of the task, even though the particular activity characterizing the function may vary somewhat in the different phases. For the revised taxonomy, two general phases in the accomplishment of any task were considered: the planning or organizational phase, and the implementation phase. It seems quite likely that at some point in the future this dichotomous category system will have to be expanded and more phases explicitly recognized. One phase, in particular, that may characterize most tasks but is not dealt with here, might be called the reconsolidation or feedback phase, that would normally occur at the end of the task. It is not considered further here, because it is usually quite similar to the orientation or planning phase for the next task.

In the section that follows, the functions in the taxonomy are organized into five general categories: orientation, resource distribution, timing functions, response coordination, and motivation. Each function is described in detail, beginning with a conceptual definition of the function followed by a description of how the function would appear in each of the two basic phases of the task situation: the planning or organizational phase, and the implementation-action phase. Where appropriate, there is a section describing distinctions between two closely related functions.

The Team Function Taxonomy

The following section presents a detailed description of the revised taxonomy, which is summarized in Table 1. This is the taxonomy that was revised by Shiflett et al. (1982), and was the one initially used in the present effort. Modifications in the taxonomy suggested by findings in the present research are discussed later in the paper. In general, each function description begins with the current working definition and includes the original definition provided by Nieva,

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TABLE 1

Taxonomy of Team Functions

A. Orientation Functions

   1. Information exchange regarding member resources and constraints

   2. Information exchange regarding team task and goals/mission

   3. Information exchange regarding environmental characteristics
       and constraints

   4. Priority assignment among tasks

B. Resource Distribution Functions

   1. Matching member resources to task requirements

   2. Load balancing

C. Timing Functions (Activity Pacing)

   1. General activity pacing

   2. Individually oriented activity pacing

D. Response Coordination Functions

   1. Response sequencing

   2. Time and position coordination of responses

E. Motivational Functions

   1. Development of team performance norms

   2. Generating acceptance of team performance norms

   3. Establishing team-level performance-rewards linkages

   4. Reinforcement of task orientation

   5. Balancing team orientation with individual competition

   6. Resolution of performance-relevant conflicts

From Shiflett, Eisner, Price, and Schemmer (1982)

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Fleishman, and Rieck (1978), where such a definition was available. Following that are descriptions of how the function might appear in different team settings and in each of the two basic mission phases--the preparatory phase and the execution phase. Where appropriate, distinctions between functions are discussed, including some of the difficulties that were encountered in making these distinctions.

Orientation Functions

Definition: As defined by Nieva, Fleishman, and Rieck (1978), Orientation Functions involve "the processes by which information necessary to task accomplishment is generated and distributed to relevant team members." These functions are intended to instill and maintain awareness of the overall status of the team. They may include information exchanges regarding team tasks, goals/mission, member resources and constraints, environmental characteristics, and priority assignment among tasks.

In the preparatory phase, Orientation is prevalent in all activities, but at times may be indistinguishable from informational activities directed at planning for the execution or implementation of other functions. The "orientation" may come as a by-product of the fact that all team members are usually together during this phase, as in a formal briefing period. In the execution phase, Orientation is usually ad hoc information which updates team members on the current status of the internal and external environments.

The four Orientation subfunctions will now be discussed in turn.

1. Information Exchange Regarding Member Resources and Constraints

Definition: This informational function serves to make team members aware of each other's resources and capabilities. It includes exchange of information about team member status and resources such as equipment and materials available for task performance.

In the preparatory phase, this information exchange reflects fairly stable and predictable attributes of team members (knowledges, skills, and abilities)--attributes that are relatively constant across varying

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task environments. The information may also include messages about physical resource availability and dependability. Knowledge of member skills and abilities is often assumed from the amount of previous training and experience a person has had in the existing task setting. Characteristics such as dependability and reliability in getting the job done, however, are more likely to become known after team members have worked together for a period of time. Since this process is not always visible with short-term observational techniques, additional information on the function often needs to be obtained through interviews with team members. This type of information exchange allows for a matching of abilities to jobs on a more skill-specific and permanent basis.

In the execution phase, the information exchange reflects the status of team members in a more spontaneous and emergent situation. It includes messages about team members' ability or inability to continue in their designated roles, availability for assignment to new tasks, and capabilities as a result of conditions in the immediate task environment. This type of information provides messages about team member status and thus contributes to group awareness of how members are faring in emergent and unstable conditions.

In order for this function to occur in the execution phase, there must be a task environment that allows for an exchange of information (which is often verbal). Additionally, Information Exchange Regarding Member Resources and Constraints may be facilitated by previous plans for information dissemination. Rules such as how and when communication should occur can be established.

2. Information Exchange Regarding Team Task and Goals/Mission

Definition: This function involves disseminating and eliciting information to establish and clarify exactly what the unit is to accomplish.

In the preparatory phase, this function involves specifying the type of operation desired and the intended team actions. Information to provide a clear understanding of the overall plan is supplemented by details about tasks and activities which the unit must undertake in

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order to achieve the team mission. This function entails distributing information and conducting discussion (including questions and answers) to the extent that it is necessary to clarify to the team members what is to be done. The objective is to provide team members with a common goal and an understanding of the role they are to play in accomplishing the goal.

In the execution phase, this function is reflected in information regarding the current status of the team's mission and specific tasks. Changes in the task or mission as a result of emerging conditions, as well as "progress reports" on how the team is doing in accomplishing its tasks in terms of both speed and quality, are also reflections of this type of information exchange.

This function requires an environment in which information exchange can occur--that is, one in which there is adequate time for discussion to take place. The communication pattern or manner of distributing task and mission information is a critical aspect of this function. For example, factors such as which team members are involved in the information exchange session, and how many people or channels the information is passed through, will affect the extent to which individuals have a clear and comprehensive understanding of the unit mission and its component tasks.

3. Information Exchange Regarding Environmental Characteristics and Constraints

Definition: This is an information function serving to provide team members with knowledge of situation-specific conditions and factors that will influence the manner in which mission tasks are performed. Pertinent information includes: (a) external support (resource availability, assistance, and reinforcement from extended teams); (b) opposition data (size, location, resources, characteristics, and expected strategies of the enemy); and (c) environmental conditions (terrain, boundaries, weather, visibility, and noise level).

This information, in addition to mission and task information, allows team members to match plans with specific details of the situa-

tion. It provides data to adapt mission plans and devise strategies to fit conditions in the environment, thereby tailoring resources and options to task demands. By giving team members an idea of what to expect, special plans for performing in a restrictive work environment, adapting to resource deficiencies, and capitalizing upon known advantages can be made. As with most other information exchange functions, an environment or situation conducive to information dissemination and discussion is needed.

In the _preparatory_ phase, this information exchange reflects the best estimate of the current or expected situation. In the _execution_ phase, the information exchange reflects emerging changes in the situation and is often a prelude to the occurrence of other functions designed to adjust the team's manner of dealing with its environment.

4. Priority Assignment Among Tasks

Definition: This function involves adjusting a formal task/goal to fit estimated or emerging restraints on resources and time. In this function, the task or mission is defined or redefined not only to reflect the mission as assigned from external sources but also to reflect team capabilities. Resources and time are seen as being either constant or beyond control, thus requiring the task or mission itself to be the focus of the function.

Two types of prioritization are included:

1. Ordering of specific subtasks including those which should be done _without fail_ and those that can be completely eliminated due to lack of time or resources.

2. Altering the definition of adequate performance by prioritizing qualitative aspects of a specific mission.

In the _preparatory_ phase, priority task assignment entails _establishing_ priorities of work (the importance of tasks) through clarifying the relative order in which the tasks should be performed. This function may not be as visible as others, in that task priorities are often standard operating procedures or are implicit. The function may include stating contingencies under which the necessity to prioritize tasks

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arises. Such contingencies may be overload conditions such as insufficient manpower, time limitations, and environmental constraints necessitating the accomplishment of some tasks before others, or instead of others.

In the execution phase, priority task assignment involves altering priorities of work in response to the ongoing situation. Orders such as "forget that for now" would be examples of adjusting task priorities in response to overload or situational changes.

Resource Distribution Functions

Definition: Resource Distribution Functions focus almost exclusively on member resources and equipment and how they are distributed in an effort to accomplish a task. Although consideration of task demands is involved, the task and other characteristics of the situation basically remain constant while resources alone are adjusted. This function category may involve two subfunctions--Matching Member Resources to Task Requirements and Load Balancing.

1. Matching Member Resources to Task Requirements

Definition: This function is defined by Nieva, Fleishman, and Rieck (1978) as "what is typically referred to as division of labor." Its purpose is to distribute member resources in the task in such a way as to maximize effective utilization of member skills. The end result is a decision about who will do what. The basis for making the decision is who, in terms of availability or by nature of the resources they offer, are best able to perform the task in the manner necessitated by existing conditions. If skill/resource assessment is not involved, then the distribution of resources is a Load Balancing Function (to be discussed later).

In the preparatory phase, this function takes the form of eliciting or confirming skills and assigning team members to specific positions. This may include "dry run" testing to confirm the match. It may also include contingency plans where more than one position is identified as needing some skill and vice versa.

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In the execution phase, the function may involve selective replacement or redistribution of skills/resources where matching of resources with task needs is consciously considered. Depending on the urgency of the situation, this function may degenerate into Load Balancing (redistribution of resources regardless of a skill-task match).

Response contingencies which may determine whether or not the function occurs include the following:

A. Knowledge of member resources is related to prior exchange of information about member resources and constraints, an Orientation Function. Types of resources considered under this function include: skills and knowledge (especially job related); physical abilities (e.g., speed, strength, endurance); traits or anticipated behavior patterns (e.g., reliability, temperament, stress response); and motivation.

B. Equipment resources.

C. Knowledge of specific task requirements includes not only tasks that must be performed, but also subtasks and the specifics of accomplishing them, as well as the abilities required for their successful completion.

D. Availability of resources necessary for achieving the match, including sufficient numbers of qualified and willing team members and equipment for the job.

E. System of task assignment includes the climate allowing for a match of skills with needs regardless of rank and grade of performer.

F. Availability of time for planning and decision making.

2. Load Balancing

Definition: Load Balancing involves adjusting member resources to task/goal requirements in such a way that there are adequate personnel at all points in the system (i.e., for all subtasks). The purpose of the function is to ensure that no subtasks are short of personnel while other subtasks are overstaffed. The function does not involve a sophisticated matching of skills with task requirements, but focuses almost exclusively on numbers of people on a particular job. Because of its relatively unsophisticated nature, the function tends to occur most

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clearly in an adaptive mode where quick, on-the-spot changes are neces-
sary during actual implementation of the tasks.

In the preparatory phase, Load Balancing takes the form of develop-
ing contingency plans regarding how and when to redistribute resources.
No implementation actually occurs other than establishing cues, etc. In
other words, this is a planning function that involves anticipating
possible overload conditions through monitoring, and establishing plans
and procedures for dealing with the overload.

In the execution phase, Load Balancing is an adaptation process, in
that it occurs as a result of ongoing changes in the task/environment,
and takes place as soon as the need is detected and the appropriate
activation cues occur. In most cases, it is a compensatory process in
which there is an effort to identify and deal with conditions that
constitute a task overload or the possibility of an overload situation
arising. The function includes mechanisms for identifying and detecting
overload, alerting team members to the situation, and responding through
changes in manpower allocations. The redistribution of personnel may be
temporary or permanent. Load Balancing can occur as:

A. A monitoring activity that does not result in subsequent
    actions because overload has not occurred.

B. Actively anticipating conditions that may result in over-
    load situations and implementing changes to allay impend-
    ing imbalances.

C. Identifying and responding to existing overload symptoms
    in order to correct the situation once it arises.

Overload or imbalance occurs in situations where a team member can-
not accomplish the tasks at hand or within his/her domain without a
change in existing conditions. In Load Balancing, the method of re-
sponding or coping with an imbalance or threat of overload is through
member assistance in performing the task (as opposed to eliminating the
task, which would involve the Priority Assignment Among Tasks Function).

An emergent situation in which a critical task arises without a
designated performer to accomplish the task may also constitute over-
load. One or all of the following factors may contribute to an overload

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situation which may, in turn, precipitate the activation of some adaptive function:

A. Inherent task requirements such that the task(s) cannot be accomplished under existing manpower arrangements. These requirements include physical demands of the task and task complexity/difficulty (where resource matching functions are not a viable or selected response).

B. The volume or number of tasks to be performed (where task prioritization or elimination is not a viable solution).

C. Time constraints on task accomplishment (where shortcuts or omissions are not elected responses).

Response contingencies are factors and conditions which may affect whether or not the Load Balancing Function will occur in response to overload. These contingencies include:

A. Awareness of the overload situation and knowledge of the need for Load Balancing.

B. Knowledge of the appropriate response to overload (who should do what) which may be determined by personnel availability or may have been established by standard operating procedures, contingency plans, or predetermined roles.

C. Availability of necessary resources and opportunity for action (e.g., other task demands on the prospective responders; equipment needed for the task; external obstacles to responding).

D. Task/situation criticality as determined by the possible consequences of not responding to the overload--that is, the tradeoff between reacting by Load Balancing and failing to respond to the situation. (Note that there is a possible overlap of two or more functions here, with the distribution decision also based on a priority assignment decision within the scope of the Priority Assignment Among Tasks Function.)

E. Desire/motivation to respond which is affected by the interpersonal dynamics among team members, team unity, morale, etc.

Load Balancing must be distinguished from Matching Member Resources to Task Requirements. While the latter involves matching team member skills to task requirements, in Load Balancing a member-task assignment

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is based on availability. Often the distinction is not observable, since in most intact teams all members have a common core of skills-- physical strength, basic military skills, etc.--and any team member may lend his/her assistance to an overload task. It is possible that these two functions may reflect differing degrees of a single function--for example, a general resource/task matching function in which sophistication of the match increases from none (any warm body will do) to a complex skill/task analysis. In this case, Load Balancing would represent the end of the scale where minimal matching occurs.

Timing Functions (Activity Pacing)

Definition: Timing functions involve time as a major component, and organize or coordinate resources in a manner not possible without a chronological component. Activity Pacing is the extent to which a team changes the timing or speed of its task performance to facilitate the team mission. This function is characterized in Nieva, Fleishman, and Rieck (1978) as "highly related to response coordination." The purpose of the function is to ensure that all individual activities are completed in the time allotted. Two levels of pacing can be distinguished--General Activity Pacing and Individually Oriented Activity Pacing.

1. General Activity Pacing

Definition: This function is oriented to the whole team--that is, all team members increase their speed, maintain their speed, or decrease their speed. It is designed (a) to maintain a working tempo such that the task will be accomplished in the amount of time demanded by the situation, and (b) to adjust the pace of work so that members will move and perform at a compatible speed. This compatible speed is one at which all members are able to operate as a unit without the work becoming fragmented due to differences in speed of performance.

In the first condition, General Activity Pacing is a function that responds to task time demands. In the second condition, it is a measure responding to different team member capabilities and a need for syn-

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chronized unit performance. For example, if member A cannot keep pace
with the unit (and other adaptive functions like Load Balancing and Time
and Position Coordination of Responses are not selected responses), the
work tempo will be reduced.

2. Individually Oriented Activity Pacing

<u>Definition</u>: This function is oriented toward a specific subset of
team members and is designed to speed them up or slow them down so that
they are operating in the same time frame. Both General Activity Pacing
and Individually Oriented Activity Pacing entail the following:

1. Monitoring to detect performance inefficiencies caused by
   inappropriate work rates (rates that do not respond to
   task time demands or that inhibit performance of the
   group as a coordinated unit).

2. Information dissemination that will maintain or adjust
   the rate of work.

3. Member response to cues/commands that serve to pace acti-
   vities.

In the <u>preparatory</u> phase, Activity Pacing is seen in information
about when the task should begin, at what pace it should occur, and
approximately when it should end. This information can include refer-
ence to specific environmental cues that help to determine the pace,
such as daylight or battle noise.

In the <u>execution</u> phase, Activity Pacing can be seen in commands or
requests intended to initiate, direct, or control the timing or speed of
events (e.g., "start when I tell you"). Behavioral actions which re-
flect Activity Pacing involve any apparent adjustment in the speed of
task performance in response to a communication or a change in the situ-
ation.

Activity Pacing is distinguished from Load Balancing in that it
involves no change in personnel or equipment distribution; it is simply
concerned with timing and speed. It differs from Orientation in that
the information exchange contains a definite implication for action
rather than being simply a statement of fact.

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Response Coordination Functions

Definition: Response Coordination Functions are characterized by Nieva, Fleishman, and Rieck (1978) as functions operating in such a way "that team member activities flow smoothly and do not interfere with each other." The purpose of these functions is to ensure that individual behaviors occur in the proper sequence, and in coordination with other ongoing activities. Response Coordination occurs particularly with tasks that cannot be accomplished independently, and that require the synchronized performance of subtasks and activities.

Response Coordination involves <u>timing</u> in order that one response occurs in a time relationship with another response. It is distinguished from Activity Pacing which also involves timing, but not necessarily in close coordination with other activities. The Response Coordination Functions include mechanisms to ensure that the unit operates in a fluid, coordinated fashion, and that team members are aware of and respond to each other's actions in a manner which enhances achievement of the group mission. Two mechanisms or processes have been delineated --Response Sequencing, and Time and Position Coordination of Responses.

1. Response Sequencing

Definition: Response Sequencing is a special case of Response Coordination in which a predetermined series of responses occurs in a specified order, but without a precise timing implication, other than temporal ordering. Sequencing involves an ordinal scale, whereas Response Coordination is on an interval or ratio scale.

In making a distinction between Sequencing and Response Coordination, the issue is again raised as to whether these are separate and distinct functions, or simply varying degrees of the same broader function. Since this is still a developmental stage of the taxonomy, it was decided to keep both functions because of their close conceptual relationship, and also because this was the organization provided in the provisional taxonomy. Nevertheless, it should be clear that a distinction is being made between two degrees of the same function (if not two separate functions): (a) Response Sequencing and (b) Time and Position Coordination of Responses.

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2. Time and Position Coordination of Responses

Definition: In this function, two or more individuals are working together to accomplish a task that fewer could not accomplish alone, either because of physical constraints or task complexity. For example, two or three individuals may lift a bridging bay ramp when one person cannot do it alone because of the weight of the ramp. Here the function includes timing <u>and</u> physical coordination--that is, the individuals must be in certain positions relative to each other as well as the ramp, and must time their activities so that all heave at the same time. The need for position coordination is also illustrated by infantry units moving forward in a wedge formation.

In the <u>preparatory</u> phase, Response Coordination Functions include planning and establishing <u>who</u> does <u>what</u> in relation to others, and <u>when</u> during the sequence of events. It may also include development of contingency plans for altering a particular sequence of events. Included here is the establishment of cues for coordinated actions.

In the <u>execution</u> phase, actual coordination and sequencing will occur in response to appropriate cues, whether preestablished or emergent in the situation. The functions will occur in a preplanned fashion, or in an adaptive, flexible manner, if the situation changes from that anticipated in the preparatory phase.

Components of Response Coordination Functions include:

1. <u>Planning</u>--i.e., designating tasks, personnel, channels of information flow, and an established cue to initiate activities requiring coordinated behaviors.

2. <u>Monitoring group performance</u> and, if necessary, delivering information and/or cues to orchestrate ongoing activities.

3. <u>On-the-spot exchange of information</u> and/or cues to initiate a chain of related and reciprocal behaviors.

Motivational Functions

Motivational functions are the most problematic functions considered in this taxonomy. First, it is difficult to operationalize motiv-

ation. Second, motivation is difficult to observe, study, and evaluate. Motivational functions often occur early in team development and, unless observed at that point, must be inferred.

Because of these difficulties, the functions were not studied in the Shiflett et al. (1982) report. They remain, for the purposes of the present study, the same as in the original taxonomy (presented below).

Motivational Functions

Definition: Involving team objectives related to the task and energizing the group to these objectives.

Among the relevant dimensions in this category are:

1. Development of team norms regarding acceptable levels of performance.

2. Generating acceptance of team performance norms.

3. Establishing performance-reward linkages for the team as an entity.

4. Reinforcement of task orientation, which includes informal rewards as well as sanctions for effective performance.

5. Balancing overall team orientation with individual competitive orientations in the team.

6. Resolution of informational, procedural, and interpersonal conflicts which interfere with task orientation.

Research Using the Functions

A laboratory tryout of the prototype scales of these functions used 19 male college students who were completely naive as to the history and development of the project (Shiflett et al., 1982). Subjects received background information on the Army teams that they would be rating, as well as instructions on the use of the scales. The scales used in the study are presented in Appendix A. This introductory phase lasted approximately 1-1/2 hours, and included the subjects' observation of the teams on videotape. In the crucial test portion of the effort, subjects observed 15 videotape segments of either mortar squads or bridge

engineer teams. Segments ranged from less than a minute to a maximum of 3 minutes in length. Subjects observed each segment twice, and then indicated on the rating scales whether or not each of the four major functions was present, and to what degree. Most of the scales resulted in moderate levels of reliability, consistent with reliabilities typically obtained for similar scales in other studies (Schemmer, 1982; Fleishman & Hogan, 1978). They clearly represent a satisfactory level for the first application of the taxonomy by relatively unsophisticated judges. Reliabilities would be expected to increase if expert judges were used or after a somewhat extended training period. Overall, the orientation function scales appear to have the highest reliabilties. Response coordination also yielded fairly high levels of reliability. There were a number of problems that indicated a need for more work before the scales would be ready for training and diagnostic applications. In particular, several of the scales yielded very low reliability estimates. The laboratory pilot test of the scales was generally very encouraging and indicated that naive subjects could indeed be trained to observe these functions with a reasonable degree of reliability.

Conclusion

The team function taxonomy represents the basic conceptual model used in this effort to develop an assessment model of tactical C^2 teams. Several issues that needed to be addressed include the usefulness of the taxonomy in characterizing tactical C^2 team functioning in terms of its accuracy and completeness, and the applicability of the particular measurement approach that had been used to describe Army teams. Both of these issues were addressed in observations of Air Force tactical C^2 teams, as described in the next section. The results of these observations, as they pertain to the model, are presented in Section V.

SECTION IV

CHARACTERISTICS OF TACTICAL C^2 TEAMS

With a general team functions framework in hand, the next logical step was to obtain information about tactical C^2 teams to determine whether the proposed model was applicable to them. Even though Shiflett et al. (1982) had demonstrated the feasibility of using the team functions approach in observing team processes in Army combat and combat support teams, there was still the very important question of determining whether the approach and its associated ratings would be appropriate in the Air Force C^2 environment[1]. In addition to determining whether team functions could be observed in tactical C^2 teams, there was a need to ascertain whether the approach could be used for assessment. Thus, although the primary goal of the data collection phase described in this section was to determine the feasibility of _observing_ functions, the ultimate goal was to convert the observations into _evaluations,_ a process described in Section V.

Selection of Tactical C^2 Teams for Study

In order to determine whether the proposed team performance framework was appropriate for studying tactical C^2 teams, information was obtained about the basic characteristics of these teams, including the important tasks performed by individual team members and the tasks performed by groups of team members. In addition, the decision was made to study the methods currently used to assess personnel performance in tactical C^2 teams in order to judge whether the proposed team functions approach would be an improvement over currently used methods. For this purpose, it was decided to study the team characteristics of two C^2 teams, selected to differ in several important ways.

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[1]The only teams that were intensively studied were two tactical C^2 teams in the Tactical Air Command (TAC). All conclusions are valid only for these teams. The term "C^2" is being used henceforth to refer to tactical C^2 units in TAC.

Method used for team selection. Three methods were used to identify tactical C^2 teams in the Air Force. First, project staff reviewed the Air Force documentation on tactical C^2 units (e.g., Control and Reporting Center, Control and Reporting Post, Wing Operations Centers). This documentation provided some information about the teams (within elements) operating C^2 systems and their size. Second, in order to get information about other team characteristics, ARRO staff made field visits to observe three C^2 teams and to discuss team characteristics. The visits were made to the North American Air Defense Command (NORAD)/20th Air Division at Ft. Lee, Virginia; the 728 Tactical Control and Reporting Center (CRC) at Eglin Air Force Base, Florida; and the 507th Wing Tactical Air Command Control Squadron at Shaw Air Force Base, South Carolina. Third, discussions were held about the availability of exercises to observe and the appropriateness of different teams for the study. These discussions were held with the project monitor as well as with Air Force personnel on the site visits.

Criteria used for selection. Two teams were studied in order to determine how much C^2 teams differ in team processes, and the extent to which a single assessment instrument can be used for different teams. Given this goal, two teams were selected using the following criteria:

- The teams differ in how proceduralized they are. In consultation with AFHRL scientists, it was decided to select teams which differ on a dimension labeled proceduralized vs. non-proceduralized. In simplistic terms, a proceduralized team has a set of instructions which are normally carefully documented and practiced. The decision path tends to be binary. A non-proceduralized team, on the other hand, appears to have more options, with multiple choices at each decision point and little in the way of general rules for decision making. Proceduralized teams generally are highly restricted in the responses they can make to specific situations, with deviations authorized only at much higher levels of authority, usually at a level or more above the unit. Non-proceduralized teams also are substantially restricted in their responses, but have a wider range of response alternatives, with decisions on these alternatives authorized at somewhat lower levels of responsibility.

- The teams differ in size. The team must be large enough so that team functions are likely to occur, and small

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enough so that ARRO staff could observe the behavior of all team members. It was expected that an ideal team would have between 5 and 15 members.

- The teams are real. Each team must operate as a true team, rather than merely being a group of people who interact informally or infrequently. The definition of Glaser, Klaus, and Egerman (1962) was used to define a team:

    1. Relatively rigid in structure, organization, and communication.

    2. Each member has a well-defined task.

    3. The functioning of the team depends on the participation of all or several members.

- The teams perform information-processing, communication, and decision-making tasks typical of Command and Control functions. Such teams work in systems that plan, direct, control and command air operations. Because of contract requirements, the selection was limited to ground-based teams.

- The teams participate in exercises in which team functioning can be observed.

- Team actions can be observed and understood. It was important for this effort that the team's actions could be observed. Teams that perform primarily conceptual or other unobservable tasks would be inappropriate.

Teams Selected for Study

One of the teams selected was the Weapons Team in a Control and Reporting Center (CRC). This team is on the proceduralized end of the proceduralized vs. non-proceduralized spectrum. The CRC has a primary responsibility to concentrate and assign air power during an enemy attack; it is a control unit interconnecting a variety of other tactical air command units. CRC personnel monitor the air space using radar; identify aircraft as hostile, friendly, or unknown; and assign aircraft to intercept, identify, and attack hostile aircraft. The primary CRC officer-level staff (including members of the Weapons Team as well as officers outside this team) are:

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- Battle Commander, who has overall responsibility for the CRC, oversees the battle, and usually is the senior person on the site.

- Senior Director, who is responsible for the overall operation of the center staff.

- Air Surveillance Officer, whose team identifies all aircraft as friendly or hostile, and transmits this information to other members of the CRC team.

- Weapons Assignment Officer, who heads the Weapons Team, which is responsible for distributing aircraft to intercept unidentified aircraft and for attacking hostile aircraft.

- Army Liaison Officer, who is present to coordinate activities between Army Air Defense Units and Air Force.

- Weapons Controllers, who ensure fighter positioning for interception and the engagement of assigned airborne targets.

The air surveillance officer and the weapons assignment officer each have several subteams under them. These subteams consist of two persons who share a radar scope. The air surveillance officer is also responsible for the plotters, who provide information to the entire unit by posting information and constantly updating it on large plotting boards at the front of the unit. The Weapons Team is headed up by the weapons assignment officer (WAO), who is assisted by the weapons assignment technician (WAT). In the configuration observed, the Weapons Team contained three two-person weapons controller subteams. Each Weapons Control subteam consisted of a weapons control officer (called the Weapons Controller or WC) and a technician (WCT).

The second team selected for study was the Fighter Duty Officer Team in the Tactical Air Control Center (TACC). The TACC is the Tactical Air Control System element with primary responsibility for command and control of theater operations. The major responsibilities of the TACC are to generate the plans (called the Air Tasking Order or ATO) for the theater actions for the following day, to monitor and adjust execution of the ATO, to display tactical air operations data, and to serve as senior air space manager, although this responsibility is usually

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delegated to a CRC. The TACC has four divisions: Combat Plans Division, Combat Operations Division, the Combat Operations Intelligence Division (COID), and the Enemy Situation Correlation Element (ENSCE). These divisions will be discussed later.

As one component of Combat Operations, the Fighter Duty Officer team has responsibility for monitoring the ATO as it is being accomplished; revising sorties in the ATO as is warranted by enemy movement, thrust and target status; and keeping the current situation displayed on the status board and the computer (if available). The members of the team include:

- Chief of Combat Operations (CCO) - directs and supervises Combat Operations, ensures that ATO objectives are attained, and adjusts the planned sorties to meet changing objectives.

- Senior Operations Duty Officer (SODO) - ensures that all personnel receive the ATO; monitors the air situation, resources and display board; and provides summaries and recommendations to the CCO regarding changes in the ATO.

- Senior Fighter Duty Officer - monitors the Fighter Duty Officers, and makes recommendations to the SODO for changes in the ATO.

- Fighter Duty Officer - monitors part of the air war. These officers are organized by specific mission applications, e.g., close air support, counter air, interdiction, and airlift.

- Fighter Duty Officer Technician - works with the Fighter Duty Officers to monitor the air war.

Methods Used to Study the Teams

This research phase involved three separate sets of data collection:

1. On-site and telephone interviews with the operational staff of the C^2 teams.

2. On-site and telephone interviews with the evaluation staff of the C^2 teams.

3. Observations of two exercises (one for each team) and associated interviews with exercise participants and the exercise staff.

Interviews with the operational staff. The Fighter Duty Officer Team studied is located at the 507th Wing TACC at Shaw Air Force Base. The CRC studied is located at the 728 Tactical Control Squadron CRC at Duke Field, Eglin Air Force Base. The information collected at both sites was used for the following purposes: to identify critical tasks performed by each team member, and to identify critical team tasks and characteristics.

One method used for data collection was a set of semi-structured interviews with the operations staff concerning the important individual and team tasks. The interview questions are presented in Appendix B. In order to ensure that all relevant team characteristics and processes were considered, the ARRO staff attempted to get both a complete picture of the team and more detailed information about variables which prior research (in non-military settings) had indicated were most significant for team effectiveness.

In order to obtain as broad an understanding of C^2 team operations as possible, including their environment and other contextual factors that might affect team performance, a broad list of discussion topics was developed. The list, summarized in Table 2, was developed from the team performance literature and the team function taxonomy, and includes variables that seem most likely to have an impact on team performance and, consequently, on the assessment of team effectiveness.

Interviews with the evaluation staff. Individuals interviewed were responsible for several different types of evaluations: Standardization/Evaluation Report (STAN/EVAL), Operational Readiness Inspection (ORI), Management Effectiveness Inspections, local evaluations, and training exercises. C^2 personnel interviewed were knowledgeable about planning, conducting, and evaluating exercises. The data were used for the following purposes: to determine what assessment methods are currently being used by the evaluations staff, and to identify the advantages/disadvantages of the current evaluation process.

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TABLE 2

Topics Discussed with Operations Staff

1. Information Exchange
2. Task Assignment
3. Resource Assignment
4. Timing of Activities
5. Coordination of Activities
6. Monitoring Performance
7. Planning
8. Team Norms
9. Decision Making
10. Task Complexity
11. Member Ability and Training
12. Relations with Other Teams
13. Clarity of Task Requirements
14. Organizational Support
15. Leadership Patterns

Two data collection methods were used: review of reports and documents on the different evaluations, including examples of the evaluations; and semi-structured interviews with the evaluation staff concerning the evaluations currently conducted. These questions are presented in Appendix C.

Observation of exercises. Two war-simulation exercises were observed: Blue Flag, in which the TACC team was observed; and a Systems Training Exercise (STE), a vehicle for training the CRC (as well as other coordinating units). The observations were used for the following purposes: to verify the information obtained in the operations and evaluation interviews, and to determine whether it is possible to observe the team characteristics identified as critical in the prior two data collection steps).

During the exercise, the ARRO staff performed two functions. The exercise was observed using a list of team variables presented in Table 2. The observer determined which critical tasks and characteristics could be observed. However, in both exercises much of the interaction among individuals in the team, or between team members and individuals outside the team, was conducted over telephones or radio. There was little physical movement. Therefore, it was very difficult for the ARRO staff to get an adequate picture of team functioning and individual behavior from observation alone. In fact, group interactions were not recorded using structured observation techniques, because it was felt that doing so would be of little use in this early stage of the observations. Instead, much of the time during the exercise was spent talking with participants and to the exercise staff so they could explain what was happening, in terms of individual behaviors, interactions, and the simulated combat situation.

Results

Following are descriptions of the basic team operations for each of the two exercises, based on the observations and interviews. The descriptions focus on team aspects that were felt to be important or critical in understanding the basic functions and operations of the teams and in developing a strategy for assessing and evaluating the teams.

Critical individual and team tasks in the CRC Weapons Team. The Weapons Team is headed by the weapons assignment officer (WAO) who is assisted by a weapons assignment technician (WAT). Under the WAO are subteams made up of dyads, each composed of an air weapons controller and an air weapons controller technician. Each of these dyads sits at a radar scope console and has primary responsibility for controlling aircraft in a particular area of the battle zone. The pilot is dependent primarily on that controller to get the aircraft to the target safely and efficiently. Because of this very close and nearly one-to-one relationship with the controller, there may be times when it is useful and appropriate to consider the pilot to be an integral part of an "extended" Weapons Team.

The WAO has overall responsibility for the Weapons Team. The WAO assigns tracks to a weapons controller or to Army Air Defense Artillery and supervises the track by monitoring the air picture on the radar scope. The WAO communicates with other teams in the CRC, particularly with the Air Surveillance Team.

The weapons controller (WC), once a target is assigned, is responsible for engaging the target and making effective intercepts. The WC communicates directly with the pilot of the intercepting aircraft, giving appropriate vectors for the target. The WC also gives the WAO some feedback on the condition of other support aircraft in the area, particularly the combat air patrol (CAP) aircraft that orbit at a certain location under the direction of the WC. The WC is also responsible for properly handing off the aircraft when that aircraft moves out of the area under his/her control. The WC keeps the WAO advised of the status of the aircraft. The WC must also help to monitor fuel status and assist the pilot in getting the aircraft from one point to another quickly and safely.

The WAO is assisted by a weapons assignment technician (WAT). The WAT is responsible for the actual external coordination, such as calling up to get the aircraft and having it scramble. The WAT also monitors the plotting boards to ensure that data are updated properly. Although the WAO has the responsibility, the WAT does a lot of the actual coord-

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inating work, particularly externally. The WAO does more of the internal coordination. The WAT would also be responsible for calling the controller technician who is assisting the weapons controller, and for correcting the controller's action when the WAT detects a problem. The WAT is responsible for some of the console switch actions, thereby freeing up one of the hands of the WAO.

The weapons controller technician works directly for an air weapons controller. This technician maintains the log of radio and radar control time and other information for each mission, from the moment a plane goes up until the time it returns or is handed over to another authority. The technician monitors radio frequencies, watches the emergency frequency, and is responsible for the console switch actions. These switch actions change symbology and provide new headings, speed and designator. The technician assists the air weapons controller, but does not communicate with or direct pilots.

In order to understand the operations of the Weapons Team, it is essential to understand the significance that communication has in the CRC as a whole. There is little physical activity involved in CRC operations. The people in the Weapons Team, like others in the CRC, sit at their stations and communicate over the telephone or by talking to others in the room. Physical activity is restricted primarily to switch actions and other manipulations of the console. Occasionally personnel will move around, but almost always for the purpose of communicating with another person in the CRC who is located at a distance within the bubble. Thus, in talking about a team function such as resource distribution, the expression of that function is almost always in terms of verbal communications. The exception to that generality involves the pilots who are controlled by the CRC. The weapons controller and the WAO may give resource distribution communications, whereas the pilot receiving those communications adjusts the position of the aircraft and thus is involved in a physical expression of the resource distribution function.

Because the CRC is like a nerve center which receives and transmits massive amounts of information, the focus of attention will be on the

communications within the CRC. This is true of the Weapons Team as it is of all other teams in the CRC. Many of the team goals involve communication, and successful attainment of the team goals can be achieved only through effective communication. To simplify the analysis slightly, the overall goal of the CRC will be defined as identifying, intercepting and destroying hostile aircraft. When communication is necessary to accomplish the objective for a single hostile target, five to seven teams become involved in the information flow, starting with the communication when a target is identified as hostile or unknown. The WAO must then determine the best way to destroy the hostile target, given the resources that are available at the moment. The WAO may then assign the target and a friendly aircraft to a weapons controller, who directs the pilot to the target.

All the nodes in the CRC are communicating with other teams within the CRC, and often with teams outside the CRC (see Figure 2). Figure 2 depicts a Weapons Team within the CRC, along with some of the formal communication channels that are available to the team. The rectangular box encloses the Weapons Team itself, consisting of the WAO/WAT team leader unit and three Weapons Controller subteams. Outside the box are major communication targets, either within the CRC or aircraft in the air space being controlled. Solid lines between the WAO and controllers, or between controllers and pilots, represent major communication links, either telephonic or radio. Lines between Weapons Teams are telephonic, but are not often used because there is little need to communicate between the teams and because their close proximity to one another allows face-to-face communication to occur with speed and ease.

A major internal communications adjunct to the verbal communication involves the plotting boards. In Figure 2, dashed lines between Weapons Controller team and plotter boards represent less crucial telephonic communications. Plotter board status is usually provided by the Air Surveillance team, but due to time lags in getting data onto the boards, the Weapons Team does communicate with plotters to help clarify current
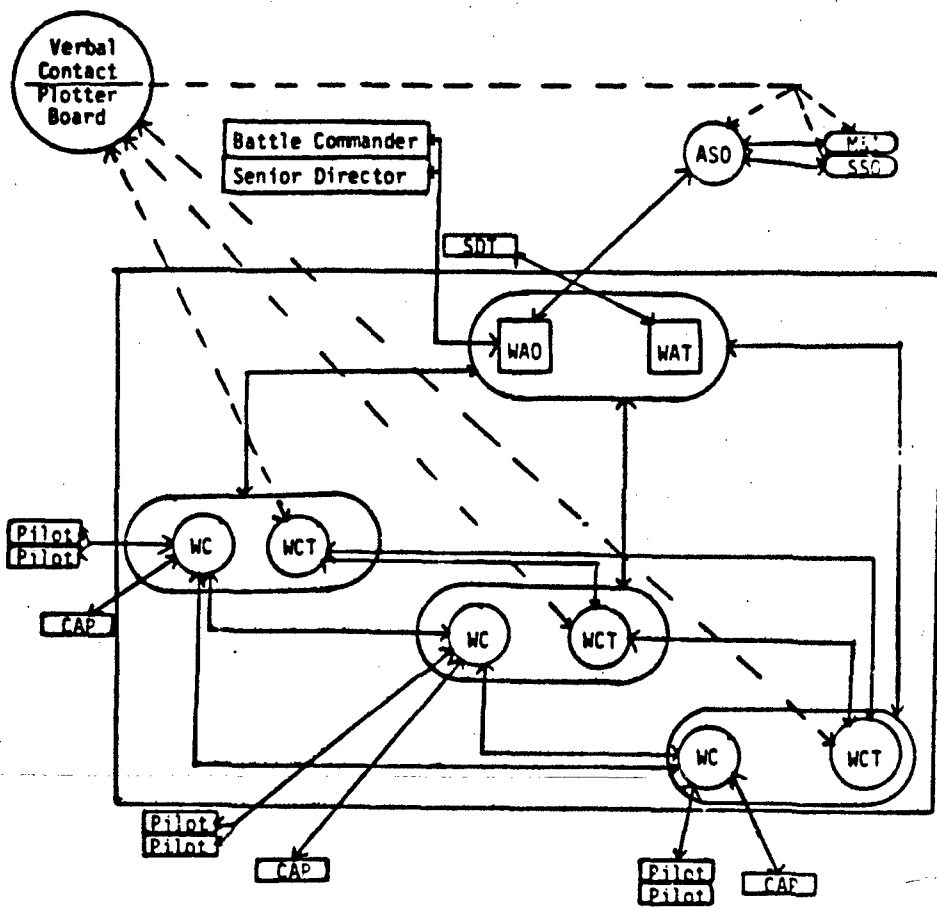
Figure 2. Communications in the CRC Weapons Team.

status of information. The figure does not show all possible formal communication links, nor does it show any of the many informal channels (e.g., face-to-face verbal communication).

The following paragraphs describe the CRC weapons team operations in terms of the team function taxonomy proposed for use as a major component of the assessment model. The description addresses the descriptive ability of the taxonomy, as well as some potential problems with the taxonomy as it currently exists. The assessment or evaluative uses of the taxonomy will be discussed in Section V.

Nearly all of the functions in the function taxonomy are present to some extent in the actions of the Weapons Teams and the pilots being controlled. The Orientation Functions appear to be crucial and represent a major activity of the Weapons Team. Orientation with respect to general goals and missions does not appear to occur often, because it is implicit as the result of training or indoctrination prior to the exercise. Information with respect to subgoals, or individual team tasks, usually defined as intercepting and destroying a target, is routinely posted on one of the larger display boards for the entire CRC to see. It is constantly being updated until the mission is completed. Orientation about the environmental characteristics and constraints is also plotted on the boards. This includes not only the location of enemy and friendly aircraft, but also weather conditions, etc. A further form of routine orientation is the use of identifying symbology on the scope. This information is adjusted and updated as new information arrives. Orientation with respect to member resources and constraints can refer to the availability of aircraft and missiles, and is provided to the CRC by the WAO, or it can refer to the status of individuals and equipment within the CRC (e.g., equipment malfunctions). Orientation with respect to priority assignment of tasks is also seen, with the WAO being the primary source of that information as well as the primary decision maker.

The Resource Distribution Functions occur most frequently in the Weapons Team. The WAO is responsible for maintaining information about available resources and assigning them to targets as appropriate. The

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WAO continually monitors the situation and, if necessary, adds unused resources or adjusts the assignment of the resources.

Timing Functions are obvious aspects of the Weapons Controller's function; they can also be seen internally when the battle situation becomes very complex and information flow is hectic because of overload. In particular, if the posting on status boards lags behind the actual situation, a great deal of effort is expended towards speeding up and "getting them current." Although this is not a task formally assigned to the weapons teams, they interact with the plotters to a fairly high degree to aid in maintaining current information.

Response Coordination Functions can be seen in the maintenance of the proper sequence of activities within the CRC, as information flows from the Surveillance Team to the Weapons Team and, in particular, in maintaining currency of the plot boards. Weapons Controllers also perform coordination when directing the CAP and interceptor pilots, in terms of the enemy targets. Very little response coordination seems to occur between Weapons Controllers, except when an aircraft is moving from one air space to another. At the console itself, the Weapons Controller Technician performs some switch actions for the Controller; these responses must be coordinated with the Controller's actions.

Many of the Motivational Functions mentioned in the team functions typically occur prior to the occurrence of an actual task, as pointed out in Shiflett et al. (1982). Therefore, it is not surprising that little evidence of these functions was observed. Most easily observed was an occasional comment reinforcing a task orientation either in response to undue socializing among members or to the fact that an enemy aircraft got through the defense lines (in effect, an error or failure).

An issue that was discussed but not resolved in Shiflett et al. (1982) had to do with system monitoring. One function that appears to occur in virtually all task-oriented situations is that of monitoring performance and comparing it to some expectation of what performance should be. To the extent that there is a deviation between actual and expected performance, an "error" exists that needs to be corrected in

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order for performance to be adequate. Previously in this effort, error detection was considered to be an integral part of the other functions. However, the significance of detecting errors in the C^2 context is so apparent that consideration is now being given to identifying a separate function category consisting of system monitoring.

The need for this type of function in the C^2 context is evidenced by the fact that there is a great deal of potential redundancy of information transmission built into the CRC system. Redundancy can be an aid to error detection in that many clues to the presence of an error exist and there are many possible "detectors." On the other hand, the complexity of the information often leads to a narrowing of the perceptual field to only those items to which a person is supposed to attend; thus, blatant errors can sometimes go undetected for surprisingly long periods of time. Telephone lines interconnect nearly all members of the CRC. In addition, the radar scopes provide nearly identical information to all teams within the CRC. A great deal of information is transmitted by face-to-face communication. Substantial orientation information is provided on a continuous basis at the front of the CRC bubble on the plotting boards. There are as many as 30 people monitoring the overall activities of the unit in addition to their own individual responsibilities. Finally, debriefing evaluations by the team members themselves after the exercise tended to focus almost exclusively on system monitoring failures. That is, questions were not concerned so much with why a particular problem arose, but with why it was not detected or resolved.

Critical individual and team tasks in the Fighter Duty Officer Team. The second of the two teams studied was from the TACC. The TACC performs Command, Control, Communications, and Intelligence (C^3I) functions for theater air operations. It is a command and control center for the air war in a given area. The TACC is responsible for developing and executing the Air Tasking Order (ATO), which specifies target priorities based on the current tactical situation and designated objectives. It is also responsible for monitoring the ATO and modifying it as required.

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The Combat Plans Division prepares a detailed ATO. The ATO is issued daily and tasks units to accomplish specific missions in support of combat objectives. The ATO is presented in sufficient detail to enable mission aircrews and tactical air control system elements to execute these missions.

The Combat Operations Intelligence Division (COID) performs four functions and is usually organized into four branches to carry out these functions. The COID processes and validates all requests for intelligence information from the Collection Management Branch; evaluates threats and determines enemy capabilities and vulnerabilities by evaluating intelligence information from all available sources (Operations Intelligence Branch); selects and prioritizes targets and determines weapons application and nominates targets for attack and reattack (Target Intelligence Branch); and provides Automatic Data Processing and display control for the COID (Data Services Branch).

The Enemy Situation and Correlation Element (ENSCE) assists the Combat Operations Division in the execution of the ATO. The ENSCE processes and provides information from a continuous flow of near-real-time information. It provides situation intelligence and warning information to other designated users. The ENSCE thus supports planning, directing, and controlling functions of a Tactical Air Force with current enemy air and ground force disposition and intelligence.

The Combat Operations Division supervises the execution of the ATO. It is responsible for conducting and integrating all tactical air operations and provides for centralized control of these operations in regard to designated objectives and the current tactical situation. Because of the size and complexity of the TACC, it was decided to focus on one of the teams of the Combat Operations Division for the purpose of the study. The team selected was the Fighter Duty Officer Team composed of the Chief of Combat Operations (CCO); the Senior Operations Duty Officer (SODO); the Fighter Duty Officer; and the fighter duty officers for Battlefield Air Interdiction (BAI), Close Air Support (CAS) and Offensive Counter Air (OCA).

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The fighter duty officers' (FIDO) responsibilities are: to know the general air and ground situation, to know the structure of the deployed Tactical Air Force/Tactical Air Control System, to be familiar with the Air Tasking Order (ATO), to maintain liaison with the duty officer counterparts in the Combat Plans Division, and to maintain the status boards located in the front of the operations area. The FIDOs are usually assigned by type of mission. They receive and review the ATO from the Combat Plans Division. They first list the types of missions, the number of each type of mission, and the resources to be allocated. They interact with the planning officers and can call them to get clarification of the ATO. They plan in detail all sorties assigned to them. When the ATO is changed, the FIDOs are responsible for planning new missions. They need to assign the type of aircraft, the type of ordnance, the number of aircraft, the specific targets, and the flight plan. Their job is to get the appropriate number of the proper type of aircraft, armed with the correct ordnance for the job, to the target and back to base or to an alternate landing site.

Once the sorties are planned, they are posted on the status boards in order of expected time over target. Liaison is maintained with the Wing Operations Center (WOC) and each of the flights is tracked by the FIDO who updates the status boards as information is received.

The Senior Operations Duty Officer (SODO) is a key individual in the chain of command, and the major interface between the fighter duty officers and the CCO. The SODO normally receives the plans and selects from the options being offered by the FIDOs. On some occasions the SODO will develop the sortie plan. The SODO is the individual who is in position to see the "whole picture;" if a contingency plan is needed, the SODO is the one who can best reallocate resources. The normal activities of both the SODO and the FIDOs require them to monitor and implement the ATO. However, special requirements are sent to them via Army requests or new intelligence information. In these cases, the SODO and/or the FIDOs need to modify and restructure the plans using the new information. They will often reassign priorities, and switch resources to meet the new priorities. If present, the Senior Fighter Duty Officer

will act as an assistant SODO, by assisting the SODO and monitoring the overall functions of the FIDOs, while at the same time assisting the FIDOs in the development of their plans.

The team observed during the Blue Flag exercise was quite different from the "classic" TACC FIDO team. The following major differences were noted in organization, structure, and function:

1. There was no formal and complete TACC in the exercise. Rather, elements of the TACC, including the Fighter Duty Officer subteam, were incorporated into the Sector Operations Center (SOC).

2. Both the offensive and defensive war were being fought at the SOC with the CRC reporting to the SOC rather than to the TACC.

3. The fighter duty officers (FIDOs) were called Base Operations Center (BOC) liaison officers.

4. The BOC liaison officers were organized by base and not by function. The BOC liaison officers were responsible for monitoring all of the fighter sorties from the base assigned to them, both offensive and defensive.

5. What would normally be the TACC Combat Operations Division was called the "Execution Branch."

6. There was no separate Chief of the Execution Branch, so that within the exercise the same individual was Chief of Operations and acted as Chief of the Execution Branch.

7. There was a Chief of Plans Branch. Thus, the organization chart had a Chief of the Air Operations Center (AOC) and an individual who served as Chief of Operations and Chief of the Execution Branch. The SODO (called the attack officer) reported to the individual who was the combined Chief of Operations and Chief of Execution.

8. There was no senior FIDO present.

9. The ATO was called the Air Tasking Message (ATM).

Although the Chief of Operations was also acting as Chief of the Execution Branch, observation of the activities indicated that the attack officer (the SODO) was functionally filling the job of Chief of Execution Branch. There was a great deal of interaction between the Chief of Operations, the attack officer, and the BOC liaison officers

(the SODO and FIDOs in the traditional arrangement). There was no obvious way to document or quantify this interaction other than a paper trail left by the forms and documents (e.g., Joint Tactical Air Strike Report Form) prepared by them in the performance of their duties. (See Figure 3 for a description of the communications in the team.)

The attack officer needs to understand the overall battle strategy and tactics, the role of the TACC, and the politics of the battle situation. Battle politics includes such items as relating with host nationals, recognition of the sovereignty of any relevant national air space, and where to go for authority to take specific actions. The attack officer does delegate certain activities to the BOC liaison officer when the task is to continue a particular action, e.g., continuing to bomb enemy ground forces. Under these conditions, the BOC liaison officers continue to prepare their sorties in accordance with the Air Tasking Message (ATM).

It was obvious from the exercise that the operations observed involved some team effort. The fact that the FIDOs were organized by base, rather than being organized by function or aircraft type, seemed to require more interaction among them. They needed to confer more on the planning of the sorties with regard to optimal aircraft and ordnance, since they were being asked to put together sorties with the aircraft and ordnance available at the base assigned to them. Since they were responsible for the total plan on a base, they needed to put together the aircraft, the pilot, the base, the return base, the fuel, the appropriate armament, etc. If they were handling aircraft, armament, or a mission with which they were unfamiliar, they would need to discuss the matter with other BOCs. When the FIDOs were organized by function or aircraft type, such interactions between FIDOs were less necessary.
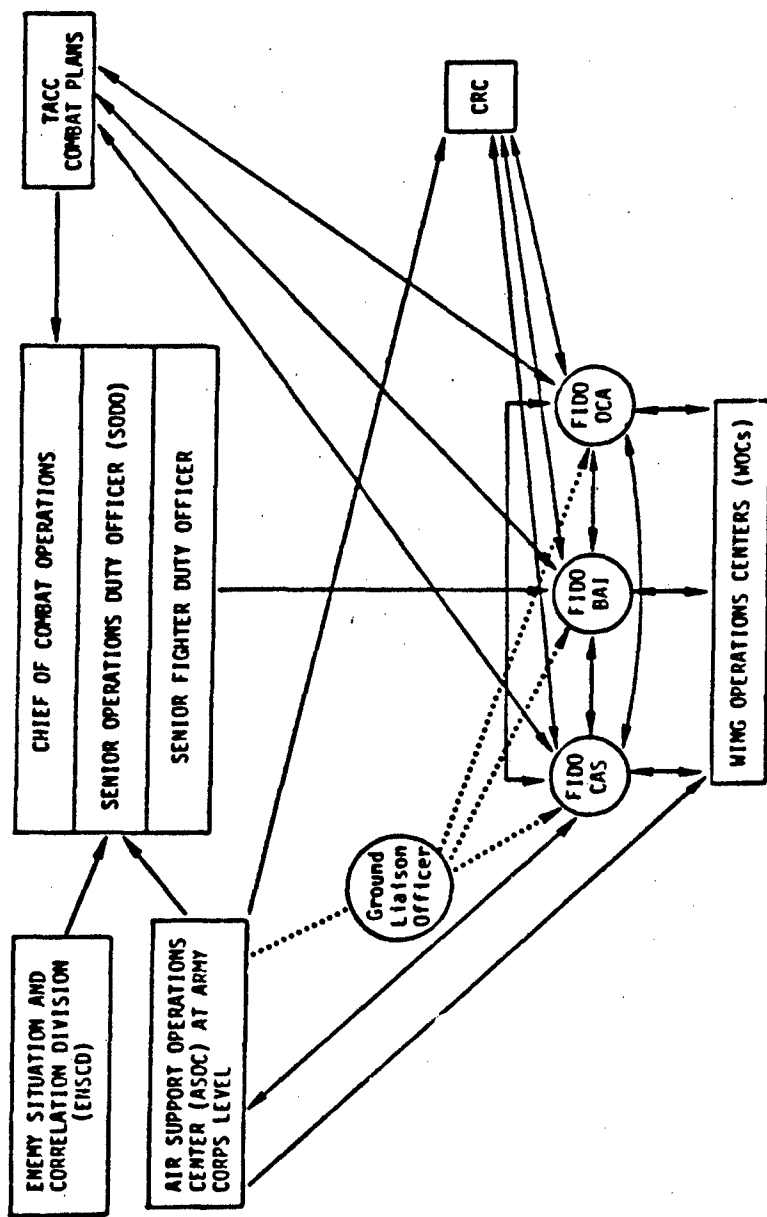
Figure 3. Communications in the TACC Combat Operations Fighter Duty Officer Team.

The team appeared to have no difficulty planning its sorties to carry out the ATM. The number of sorties assigned from the ATM did not utilize all of the resources available; therefore, the attack officer and the BOC officers called the BOCs and the Air Support Operations Center (ASOC) to find additional targets. A measure of success based on the percentage of sorties allocated and completed would have been misleading, since merely following the ATM would not have utilized all of the assets available. It was only by going out and seeking their own targets that they were able to utilize all of the assets allotted to them.

In applying the function taxonomy to the TACC, it would appear that all of the functions are present. However, much of the observable "team interaction" was with elements outside the Fighter Duty Officer Team and often outside the TACC (e.g., coordination with the ASOC, WOC, and CRC). Except for some continuing interaction among the FIDOs, and between the FIDOs and the SODO, there was little team activity. In addition to the extensive interaction outside the team, most activities concerned individual actions such as planning and decision making. The team functions that did occur are discussed below.

Orientation with regard to the tactical situation is a key initial step for the team preparing itself for combat. Each individual on the team is reponsible for being aware of the air assets and logistics support available to them, the weather in the target areas, home base and diverting bases, TAC unit status, any problems which affect the WOC operations, and intelligence updates on important environmental constraints such as "no bomb" lines, rules of engagement, and prisoner-of-war or other off-limits target areas. As the battle proceeds, Orientation continues with respect to asset attrition, the strategic situation, the changing intelligence situation, and changing target priorities. Team interactions will be among the SODO, senior FIDO and FIDOs since the SODO and the senior FIDO will be the primary sources of information updates for the FIDOs.

Resource Distribution is of major importance in the TACC subteam studied. It is the responsibility of the SODO, coordinating with the

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CCO for approval/disapproval, to see that all of the requested and planned sorties are carried out. The FIDOs must allocate the appropriate aircraft and ordnance to achieve the missions assigned to them by the SODO. The control and full utilization of assigned resources is a key function of the FIDO, and the Timing Functions are obviously important key aspects of the TACC functions. Since the routes to the target and back to the home base or alternate base are keyed to the battlefield conditions and status, it is critical to the mission's success that the aircraft leave on time. In addition, many of the targets are "time sensitive" (i.e., they are mobile targets), or the need for the action is critical at a particular moment in time such as in close air support. If timing is off, the targets may no longer be there, and friendly troops may be occupying the target area.

Response Coordination is the most critical of the team dimensions. These functions are probably more important to the TACC than are any of the other dimensions. However, most of these functions are shared with individuals outside of the primary team. The need to coordinate the activities of the offensive war (one of the major responsibilities of the TACC) is perhaps the most important aspect of mission success. Such factors as the time over target, coordination with ground troops through the ASOC, and coordination with other aircraft on electronic countermeasures, flak/SAM suppression, rendezvous with tankers, and reconnaissance, all need to be carefully orchestrated. The response coordination in close air support and air interdiction are obvious to the safety of ground troops. A major function of the FIDO is close coordination with the SODO, WOC, ASOC, and the CRC to see that all of the sorties assigned are carried out successfully. Coordination with other FIDOs occurs when additional information is needed about a particular aircraft or ordnance.

The Motivational functions found in the taxonomy are not so obvious in the TACC. Motivation is obviously present, but not directly observable in the activities that are being carried out. The level of motivation could be inferred from the heightened activity at given periods of time, or from the positive and negative reinforcements which occur

for successful and unsuccessful actions. It will be necessary to develop a procedure for assessing the motivational functions in future research.

Finally, the function of System Monotoring is obviously present and important to the TACC performance. There is a constant need to obtain feedback as to whether the mission is proceeding as it should. Each flight is followed with regard to time of takeoff, time over target, and landing time. In manual systems these data are posted on large status boards in front of the TACC. In addition, this information is presented by a computer (Computer Assisted Force Management System or CAFMS) where the system is available. The FIDOs also monitor ground aborts, air aborts, in-flight emergencies, and mission results to determine whether targets need to be restruck. If errors do occur, the impact of the error needs to be assessed immediately and appropriate actions taken. Again, in the offensive war there is little margin for error when planning and executing sorties. The time-sensitive nature of many of the targets, the changing pattern of air defenses, the changing tactical situation, and the close proximity of the forces to the targets, all make error detection and correction a very important function at the TACC.

SECTION V

PROTOTYPE C^2 TEAM ASSESSMENT METHOD

In this section, the basic elements of a C^2 team assessment method are presented. The method is based on the assessment techniques developed for use in Army settings and has been revised based on observations and interviews in Air Force tactical C^2 teams. This section begins with a general discussion of the distinctions between simple observation and assessment for evaluation. Next is a brief discussion of the conceptual model which underlies the evaluation methodology. This is followed by a discussion of the methods currently used to evaluate tactical C^2 teams. The basic requirements for a prototype assessment methodology are then presented, followed by a discussion concerning a possible measuring instrument.

Measurement vs. Evaluation

It is important to distinguish between simple observation and observation for the purpose of assessment and evaluation. The transition from simple measurement to evaluative measurement requires a set of standards. The standards serve as a point of comparison with which to compare the observed teams and evaluate their effectiveness. These standards are derived from the goals of the teams as well as from the judgment of Air Force experts as to what constitutes good performance. Currently, there are no formalized standards for effective C^2 team performance.

One model of effectiveness, suggested in Section III, is based on Shiflett's (1979b) model of team performance. The model asserts that performance is a function of individual resources brought into the task situation and weighted by the effect of various transformation variables (team functions, motivational functions, and other context and task characteristics that affect the use of individual resources in the final team product). The model requires the observation of several classes of variables: individual resources, group productivity, and the transfor-

mation variables. Because measures of team productivity and individual skills already exist, this effort has focused on the transformation variables, in particular team functions. Eventually, measures of all of the classes of variables must be properly developed and validated in order to assess the operational readiness and productivity of the team fully and effectively.

Shiflett's model of team performance did not provide any formal theory of the transformation variables. Structual role theory (O'Brien, 1982) represents one approach to resolving this problem. The team functions model used in this effort also represents a beginning in this direction. Eventually, a more formal model must be developed specifying the effect on team productivity of team functions, other transformation variables, and individual resources.

Observations of C^2 Teams

As described in Section IV, two tactical C^2 teams were observed performing training exercises. There were three purposes for these observations: to become familiar with the general operations of tactical C^2 teams, to determine the best approach to use in assessing C^2 team performance, and to determine whether or not the previously developed team functions taxonomy and measurement instruments would be applicable to assess the two tactical C^2 teams.

Current C^2 assessment procedures. Several types of assessment procedures are currently used to evaluate Air Force personnel who operate C^2 Systems: assessment of the performance of units during training exercises, assessments of operational readiness, tests of individual performance and knowledge, and reviews of paperwork.

1. Exercise assessment. ARRO staff observed a Systems Training Exercise in which the Weapons Team in the CRC participated, and Blue Flag, an exercise in which the Fighter Duty Officer Team of the TACC participated. Both exercises are war simulations which are conducted for training purposes. In both exercises, controllers observe the personnel and identify problems in performance. Problem identification is

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done within the context of supplying feedback to participants. In the Weapons Team most of the feedback was given to the exercise participants after completion of the exercise. The feedback was general, identifying problems but not citing individuals or teams that might be responsible. Because there were only two controllers, more precise assessment and diagnosis may not have been possible.

Although individualized assessment and feedback were not provided for the CRC members, general evaluations (of the Weapons Team and of overall CRC functions) were given. Timeliness was a major criterion of effective CRC performance, e.g., the time between observation of an unidentified track on radar and its identification, and the time between identification and placement of the track on the plotting board. Although excessive time lags could be identified as a problem, it was not easy, if even possible, to determine the specific actions or persons causing the delay. A second indication of problems was the noise level in the bubble. Increased noise, confusion and very loud talk all indicate difficulties. Again, the specific cause of such difficulties could not easily be determined. A third criterion used by the evaluation team was counting the number of enemy aircraft approaching dangerously close to the CRC.

In addition to this assessment of the CRC, the senior officers at the CRC discussed the exercise with the senior officers of other units involved in the exercise (the Control and Reporting Post, and the Forward Air Control Post). These discussions all concerned the outcomes of the exercise (e.g., number of enemy destroyed) and coordination between units in the exercise.

Similar assessments of C^2 personnel were provided to the participants of Blue Flag, an elaborate war scenario which trains C^2 personnel and potential C^2 augmentees in TACC operations. In Blue Flag, there is even less emphasis on evaluation and more on training. Assessments of performance are provided during as well as after the exercises. The evaluators, or controllers, suggest alternative behavior. The controllers intentionally do not evaluate performance, viewing it as a threat to the training which is the purpose of the exercise.

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For both the CRC and the TACC, there are no formal standards of effective performance. The assessors must know C^2 team operations well enough to identify problems and suggest remedial actions. There is almost no formal documentation to assist in the assessment and feedback process.

After the exercises, after-action reports are presented to unit commanders and others. The reports are very general, citing major difficulties and exercise results. The reports are useful primarily for suggesting changes in the exercise scenario, for revision of training, and for equipment modification.

2. <u>Operational readiness assessments</u>. In contrast to the assessments of performance during training exercises, which focus explicitly on training, are the assessments of operational C^2 units. These assessments are clearly evaluative in nature. The Operational Readiness Inspection (ORI) involves an evaluation of the readiness of a wing or a unit, by tasking the unit to perform a mission and then evaluating its execution. In the CRC evaluation, a scenario is developed, fighter support is obtained, and intelligence is developed for the scenario. During the ORI, the CRC simulates preparation and deployment. The CRC team then sets up its radar equipment away from the base. Fighters are brought in and the CRC is given responsibility for controlling the air space during a simulated battle.

The ORI team evaluates deployment, mobility, regeneration and, finally, operations. Both the CRC and components of the CRC (e.g., the battle staff and the component teams) are evaluated. In addition to a formal report, the ORI team speaks to members of the CRC to explain the results and obtain the participants' interpretation of their performance in the ORI exercise.

The standards for evaluation and for awarding points in the ORI are vague. The speed of evaluation in the ORI may lead to superficial evaluations. The ORI does not locate problem sources, nor does it recommend specific ways to ameliorate problems.

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Because of the expense and personnel requirements involved, there had not been an ORI evaluation of the TACC for some time. An alternative to an ORI, a Mission Capability Inspection, was being planned. Because the inspection unit performing the ORI does not have the resources available for bringing together diverse components of the TACCs for an exercise, the inspection will occur when the TACC participates in a large-scale exercise. In this paper neitner deployment nor mobility will be evaluated but, rather, the accuracy, timeliness, workload, and mission accomplishment of the divisions and teams.

3. Assessment of individual performance and knowledge. The Standardization/Evaluation (STAN/EVAL) Report is designed to provide the wing or unit commander with an evaluation of the unit's readiness to meet battle demands. The STAN/EVAL involves both the assessment of individuals and the evaluation of units. Individuals are assessed on their knowledge of the job, using written tests. Individuals are also evaluated during exercises on effective performance of work tasks.

A similar type of individualized assessment measure was used in Blue Flag. A pre-post examination was conducted during the classroom portion prior to the start of the actual exercise. A baseline survey was given before the training, and a post-test with an equivalent form was given after the end of the classroom portion of the training. Questions were directed at the knowledge of relevant areas, resources, etc. A self-appraisal form and training critique form were also used. The individual was asked to rate his or her gain in knowledge by area.

4. Assessment of paperwork. The previously described evaluations concern the assessment of performance. C^2 units are also evaluated for keeping appropriate records and reports, and providing required training. One type of STAN/EVAL involves reviewing such documentation. The Management Effectiveness Inspection (MEI) is an administrative evaluation, assessing record keeping. Like the STAN/EVAL, this evaluation method does not consider the actual performance of the units being assessed.

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To summarize, there are two general types of assessments of C^2 effectiveness. First are the evaluations given during and after exercises. These are subjective and have no specified standards for performance. They focus on training, and are intentionally non-evaluative. The procedures are very general and are neither diagnostic nor oriented to providing feedback. In contrast is the second type of assessment which is evaluative, and assesses both individual and unit performance. These evaluations focus less on behavior than does the first type. Often these latter evaluations are merely reviews of record keeping.

The first type of assessment is obviously more useful for purposes of this research, which concerns performance assessment. The absence of standards for evaluating effective performance and of some formal assessment measures increases the burden on the evaluator. Currently, the evaluator is provided few resources to assist in making assessments and providing feedback.

During this discussion, no mention has been made of team assessment. Currently there is no explicit evaluation of team performance. During an exercise, some notice may be given to a problem that is obviously the result of poor performance of a specific team. However, the team component of C^2 performance is rarely specifically studied and assessed.

Adequacy of the Team Functions Taxonomy

A major purpose for studying tactical C^2 teams was to determine the adequacy of the team functions taxonomy as a basis for evaluating these teams. In general, it was found that the team functions taxonomy could be used to capture most team-related aspects of tactical C^2 teams. Illustrations of the use of the taxonomy to capture tactical C^2 team functioning are presented in Section IV in the descriptions of the CRC and the TACC.

Although the taxonomy generally proved to be quite effective, several problems emerged that seemed to indicate that some modifications

to the taxonomy were required. In general, all of the functions currently defined in the taxonomy appear to be present to some degree in tactical C^2 teams. These functions can be observed in communications among team members. Other team functions can be seen in coordinated physical movements such as moving equipment around. However, it became apparent that certain functions occurred repeatedly but were not contained in the taxonomy. These functions dealt with system monitoring and with maintenance of procedures. Both of these functions concern error detection and feedback. System monitoring involves the checking of all system elements for errors and omissions. The consequence of such monitoring is a change in system functioning (if problems are identified) or continuation of on-going activity (if no problems are found). Maintenance of procedure involves the checking of behavior to be sure that all performance standards are being met. It is an alternate approach to maintaining efficiency. Rather than involving the detection of error, it concerns conformity to standards of proper performance.

In the original taxonomy development process, it was concluded by Shiflett et al. (1982) that system monitoring was a subcategory of each independently defined function. However, in the current effort, based on the study of the characteristics and operations of Air Force tactical C^2 teams, it was concluded that monitoring is so crucial a function that its separation from other functions is necessary to evaluate the functioning of the team effectively. The substantially more complex task and communication situation found in C^2 teams, in contrast to the typical Army teams observed in the previous study, strengthened this need.

Observations also led to considering the possibility of adding yet another function to the taxonomy to reflect the frequently occurring activity of maintaining proper procedures. The addition of these two functions to the taxonomy really reflects a finer definition of the previously defined functions. In fact, it seems inevitable that as work proceeds in developing and using the taxonomy for various purposes, more functions with narrower definitions will appear (Fleishman & Quaintance,

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1984). Therefore, even this revision of the taxonomy is not likely to be final.

Adequacy of observation and measurement procedures. A major problem that seemed to emerge from observations of the C^2 teams involved the appropriateness of using the seven-point rating scales previously developed to measure the team functions in Army teams. The scales seem to be useful when rating observable behavior, but appear to have major drawbacks when the functions are occurring in a communication mode. More appropriate measurement techniques may involve simply ratings of present/absent, frequency, or timeliness. In other words, when a function is served through a communication, the measurement will simply indicate that it occurred and when it occurred.

Some of the difficulties found in using the seven-point rating scales in the Shiflett et al. (1982) project may be the result of the inappropriateness of such scales for rating team dimensions. It may be that the team functions do not vary quantitatively but, rather, differ in an all or none fashion. For example, team members might establish work priorities or they may not. It may not be possible to make any finer discriminations than the occurrence or non-occurrence of the function. If this is true, then it is more appropriate to use a two-point rating scale of occur/not occur for these dimensions rather than a scale which differs in degree.

Even if it is possible to rate team dimensions using a multi-point scale, it is believed that the initial version of the scale should be of the simpler two-point version. As mentioned previously, many behaviors in C^2 teams are difficult to observe. In addition, the complexity of behavior in such teams imposes great demands on the evaluator. Considering both of these difficulties, it seems appropriate to begin with a rating format that is simple to use. If the initiating ratings can be further discriminated, then more elaborate scales can be developed after initial testing.

Even though fairly definitive statements are being made about suggested changes in the measurement technology, it should be noted that

the team dimension scales were not used to any great extent during the on-site observations. Actual observation of the functions on an incident-by-incident basis was sufficiently difficult that the measuring devices were not used during the observation; instead, interviews with personnel were relied upon heavily. Thus, any final resolution of the issue of binary vs. multiple-category scales awaits the development of appropriate observational techniques that will permit the monitoring of the content of communications.

Suggested solutions to these problems will be elaborated on in the discussion of a suggested prototype assessment methodology, presented next.

Prototype Assessment Methodology

An effective assessment procedure requires an evaluation model, an effective measuring technology, and standardized administration procedures.

An essential requirement for assessing performance in tactical C^2 team settings in particular is the presence of a highly knowledgeable evaluator. The complexity of the situation, combined with the subtlety of many of the functions, requires a much higher degree of knowledge and sophistication on the part of the evaluator than would typically be required in many other team settings. It seems quite apparent that an effective evaluator would have to be more knowledgeable about C^2 team operations than the ARRO project psychologists currently are. This level of sophistication comes only from experience or extensive observation and contact with the units.

The use of instrumented observation also seems essential for evaluating tactical C^2 teams. The large percentage of communication-based functions, most of which occur on radio and telephone, means one must observe with the ears as well as the eyes. In order to do this effectively, the observer must be linked into the communications system. The vehicle for accomplishing these requirements is already present in the computer technology used in some tactical C^2 settings. An example of

such an instrumented approach might be the use of an observer's console which permits the evaluator to tap into any person's communications. The time of occurrence of a communication, as well as the origination and terminus points of the communication, can be displayed on a console and recorded on magnetic tape.

For evaluation purposes, it is important that the measured functions be easily visible or observable, whether by computer or the human eye. Eventually, the evaluations will be performed by Air Force staff. It is important that the functions be easily observable without extensive psychological training, and have a reasonable amount of face validity in the sense that they have an obvious and meaningful relationship to agreed-upon standards of team effectiveness.

Although it appears that hand-scored scales based on direct observation of team functioning may have limited utility in tactical C^2 settings, they will still have an important role. An example of a possible measuring device is presented in Appendix D, utilizing the binary or present/absent format for describing the function. This rather simple format provides three types of assessment information:

1. The occurrence of the function.

2. The time it occurred, from which such evaluative measures as timeliness can eventually be derived.

3. The reactivity of the function--whether it was initiated by the individual (proactive) or occurred as a result of an action or request by another individual (reactive). This type of information may be useful in assessing the effectiveness of team function occurrence or skill in using team functions.

Frequency of Observations

Since C^2 exercises and missions can extend over a period of time from 4 hours to 4 days or longer, the issue of how much observation is adequate becomes crucial. The nature of most tactical C^2 operations is such that the procedures are fairly repetitive, and observations over the entire period will often be highly redundant. Once an adequate base of information is obtained, additional measurements will not serve a

useful purpose. On the other hand, it is essential that a minimum base which covers all the different phases and missions be developed.

The most effective method of observation that satisfies the requirement for a minimum data base while avoiding excessively redundant observations is to use a sampling protocol that specifies what should be observed and how often. The most common sampling procedures are episode sampling and time sampling. In time sampling, predetermined time frames are sampled and all other time frames are not. For example, observations might occur during the first 5 minutes of each half-hour period of an exercise. This is a useful sampling device for situations in which activities are relatively similar or cyclical over a long period of time. Episode sampling recognizes the existence of complete, self-contained, episodes or missions that occur within the longer overall exercise time frame. In this procedure, a certain proportion of episodes are observed from beginning to end. This is particularly useful for the tactical C^2 situation, since most missions have clearly defined beginning and ending points. For example, a typical CRC episode or mission begins with the entrance of an unidentified aircraft into controlled space, and proceeds until the aircraft is disposed of by identifying it as friendly or destroying it if it is hostile. The Air Force personnel interviewed indicated that it was also important to observe teams during non-episode periods, since a great deal of information about the team can be obtained at that time. The drawback to the episode sampling appraoch is that it does not allow determination of the state of tactical C^2 teams during non-episode periods. Consequently, a combination of the episode sampling and time sampling procedures is proposed.

The suggested sampling procedure is a prototype and would have to be adjusted for each C^2 team observed. In general, observations will occur at periodic intervals over the entire exercise period. The length of a sampling period would be adjusted to be appropriate to the overall length of the exercise. In other words, a 4-hour exercise would have shorter sampling periods than would a 4-day exercise. A 4-day exercise might even have two intervals defined, a short and a longer one. The

short interval might be 1 hour, and the longer interval 4 hours. The observation protocol would require that each team member being observed by an evaluator be observed at least once each hour or episode. An observation period per person might be 5 to 10 minutes. At the end of a 4-hour interval, a review of the episodes sampled would be made, and a sampling adjustment would occur to be sure that tasks not covered during the first interval would be adequately observed during the second interval.

In order to cover all types of episodes or missions effectively, an evaluator will need to know as much as possible about what is going on in the exercise. This means that evaluators will have to spend a substantial amount of time preparing for the observations. This preparation will require not only extensive knowledge of the type of team and exercise to be observed, but also a detailed review of the exercise scenario or tasking order. Different types of missions can then be identified and sampled using a stratified sampling procedure. This information will also permit the observer to make sure that each person is covered at least once each time period for a complete mission.

Summary

This section has reviewed the current state of Air Force C^2 evaluations, as well as the effectiveness of the proposed team functions measurement methodology. A revision to the team functions taxonomy was made, and samples of procedures for measuring these functions were presented. The need for supplemental instrumentation was discussed. Finally, a prototype sampling protocol was proposed that would permit adequate observations without excessive redundancy. In the next section, some remaining methodological and theoretical issues will be discussed, and some topics for future research will be proposed.

SECTION VI

UNRESOLVED THEORETICAL AND METHODOLOGICAL ISSUES
AND FUTURE RESEARCH NEEDS

Issues in Team Assessment Research

Purposes of assessment. Before observing and assessing a team, it is first necessary to determine the types of things to observe and the method used to record the observations. How are these decisions made? The choices will all depend upon the goal or purpose of the observation. The requirement for articulation of goals is not meant to place an unnecessary limitation on the data collected, or the number of purposes that can be served. Perhaps the best way to illustrate the extreme importance of clearly defining one's goals in a team research setting is to contrast the team function taxonomy research approach leading up to the current effort with the research program on task-oriented teams currently being conducted by Richard Hackman (1982).

Hackman's research is designed to fill a major void in the knowledge of task-oriented teams. As noted elsewhere, the vast majority of research on groups has been on small, social or therapy groups, with less interest or concern for task-oriented teams. Consequently, little is actually known about team functions in a task-oriented group. Hackman chose to study only task-oriented teams in organizational settings and to use methods to provide a relatively rich and detailed description of teams and their contexts. His research program requires the use of multiple observational methods and is also designed to obtain information for a wide variety of team types, settings, and tasks. The goal is to describe as completely as possible a team, its task, and its setting.

In contrast, the team function taxonomy research program had as its initial focus the identification of team functions that served to make effective, synchronized work possible through the appropriate utilization of individual skills (Nieva et al., 1978). The taxonomy is being used to diagnose problems in tactical C^2 teams for training purposes.

Compared to Hackman's, the measurement approaches proposed require much less time and fewer resources, and only those team characteristics relevant to increasing team effectiveness are rated.

For this effort, it is proposed that a team diagnostic assessment technique be developed within the context of a model of team behavior. It is believed that measure development should be in the broader context of testing a model that relates those team functions to overall team performance. In this type of research strategy, it would be inappropriate to observe only team functions while ignoring individual skills and performances or overall team productivity. Clearly, all must be observed. This approach is being suggested because it combines the analysis of both the individual abilities and team functions that need to be considered for training. Placing the assessment instrument within the context of a model of team processes would allow selection of those variables that are most important for team effectiveness.

Relative emphasis on measuring idiosyncratic characteristics of tactical C^2 teams or general team characteristics. The emphasis in this study has been on the development of a procedure for measuring and diagnosing the effectiveness of tactical C^2 team performance. The approach taken has been to review and refine a generic assessment model developed in previous research by ARRO to evaluate team performance. The model was intended as the basis for a generalized assessment tool, applicable to all teams.

From the observations of tactical C^2 teams during exercises, it was determined that the team functions taxonomy model can be used is a basis for developing an assessment tool for tactical C^2 teams. While the current indication is that such a generic model is in fact useful, the ultimate value of such a tool in assessing C^2 teams must await an empirical test of the team functions approach in the field.

One of the important characteristics of the team functions approach to be further investigated is the question of whether all the dimensions of the approach are in fact applicable to every C^2 team to be evaluated, and further, whether the contribution of each dimension is in the same

weighted proportion assigned a priori. Once the approach is fully
developed, it is anticipated that a weighted algorithm will be developed
for arriving at an overall team score. A major question which must be
addressed in any future field test of the system is whether or not all
dimensions are applicab $\colon$ to every C^2 team, and whether the dimension is
applicable to the same degree to every team.

Relative emphasis on the assessment of individual and team perform-
ance. The present effort focused on the team aspect of C^2 unit perfor-
mance. As a result, the assessment instrument proposed concerns only
team dimensions. The role of individual performance has received much
less attention in the research because of the goals of this effort. The
emphasis here, however, should not be used as an indication of the rela-
tive importance of individual versus team factors in tactical C^2 effec-
tiveness.

The research literature indicates that both individual and group
variables affect group effectiveness. There have been a number of
studies showing that member ability, operationalized either as general
intelligence or as specific proficiencies, has a strong influence on
group outcomes (see reviews by Heslin, 1964; McGrath & Altman, 1966).
There has also been research, with less clear and consistent findings,
showing a relationship between individual team member personality traits
(e.g., adjustment, sociability, dependability) and team effectiveness
(see the review by Heslin, 1964). Team characteristics, e.g., communi-
cation and cooperation, acc unt for some additional variance in predic-
ting team effectivness (Deutsch, 1949; Miller & Hamblin, 1963; Naylor &
Briggs, 1965; Steiner & Dodge, 1956). Past research suggests that such
factors as the difficulty or complexity of the task, and coordination
needs, all influence the extent to which team functions affect perfor-
mance (see the review by Bass, 1982). For example, the task that is
highly difficult or highly complex, or has a high degree of coordination
requirement, will have a much greater dependency on the effective util-
ization of team functions than one in which team members are basically
operating independently of each other, even though their individual
efforts may be pooled into some sort of team productivity.

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At this point, no answer can be given to the question of relative importance of team and individual factors, since their importance in tactical C^2 teams is not known. The relative emphasis on individual and team assessment depends on the relative importance of these variables in affecting team productivity, and on the purpose of the assessment.

It is proposed that research be conducted, within the context of tactical C^2 teams, to determine the relative importance of these variables. Since the assessment of C^2 performance is being conducted for several purposes, each purpose will be considered separately. First, what should be the relative emphasis on team and individual variables in assessing tactical C^2 team performance? From the assessment perspective, there should be a regression study in which both team and individual level variables and team productivity are measured. The variables that best predict team effectiveness are those that should be most heavily weighted for assessment purposes. A similar research study could be conducted considering training. There is a need to determine which variables are most significant in effective training.

What should be the relative emphasis on team and individual variables in diagnosis and remediation of tactical C^2 team problems? Here, research is needed to identify problems in C^2 teams and their probable causes. Interventions then need to be developed and undertaken. The relative extent to which team- and individual-based problems are amenable to change should determine the relative weight given to these variables from a diagnostic and remediation perspective.

Translation of assessment data into diagnostic/prescriptive feedback. A useful model for planning this translation process is derived from the organizational development literature. Kolb and Frohman (1970) posited a sequence of steps involved in providing and evaluating feedback; these are described below:

● Step 1 - Diagnosis. The assessment instruments that will be developed in this research effort can be used for C^2 team assessment and diagnosis. These instruments will include directions about what data to collect, the sources to be used in collecting the data, and how the data should be collected.

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Since training is defined as a primary context within which the team functions measures may be used, then the focus of the research strategy must be on developing measures that will provide adequate assessment of team performance as well as effective feedback on performance of team functions. This feedback and, therefore, the assessment, needs to be as specific as possible in terms of individual behaviors. It is also necessary to tie the effective performance of team function tasks to overall team performance. Otherwise, team members will have no real motivation to improve in these areas, since ultimately the overall outcome is the only performance that counts. In order to provide specific, behaviorally based feedback, it will be necessary to utilize observation and rating scales that provide that kind of information.

● <u>Step 2 - Planning the intervention</u>. In order to use the data obtained in the prior step for diagnosis and feedback, research studies need to be conducted. First, there is a need to determine the team variables and individual level variables that cause problems and reduce C^2 team effectiveness. Second, research must be undertaken to identify effective interventions to reduce these problems and improve effectiveness. This research, when completed, will have linked assessment of variables to diagnosis of problems, and diagnosis to interventions.

● <u>Step 3 - Action</u>. The intervention may involve feedback, training, discussion of team problems and planning for change, clarification of responsibilities, or reassignment and better placement. Since the assessment procedures will primarily be used for training, feedback is the key intervention strategy.

In order to use the team functions scales for feedback, the evaluators themselves must be trained in observation procedures and the specifics of team functions. Next the evaluators must be trained to rate the team using the scales, and to provide feedback based on the rating. A training session might involve a simulation lasting several hours in which multiple attacks occur. In an introductory training mode, that simulation would be broken down into a series of short episodes, each containing a complete, small-scale scenario such as handling one track or set of tracks from beginning to end. When the track

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has been handled, the exercise would stop for immediate debriefing in which both positive and negative feedback on critical functions is provided. In more sophisticated full-scale exercises, the full-length simulation would occur with formal procedures for on-site, immediate feedback (positive as well as negative) while the exercise is proceeding. It may be necessary to have a large number of trainers or observers to implement this procedure, since in a complex scenario one trainer could not provide feedback to more than four or five team members. The precise span of control for one trainer would be empirically determined by the complexity of the exercise.

• Step 4 - Monitoring the progress of the intervention. This involves determining whether the intervention is being implemented properly, and whether it is being accepted.

• Step 5 - Evaluation of effects and costs of intervention. At this point, an assessment must be made to determine whether the problem has been reduced and whether the team is operating more effectively.

Future Research

Completion of the instrument. The first follow-on work should be a two-part effort, with the first step directed at a sharpening and refining of the model itself. There needs to be a review and revision of the team dimension descriptions and definitions in light of the findings of this current effort. The definitions of the dimensions need to be made more precise and the distinctions among the dimensions clarified and specified. Definitions must also be developed for the two new functions: system monitoring and maintaining proper procedures.

The steps involved in instrument completion are:

1. Revision, by ARRO staff, of the definitions of the team dimensions.

2. Definitions of the two new dimensions.

3. Review of the definitions by AFHRL researchers and Air Force C^2 experts. The review would involve an assessment of the clarity of the definitions and the degree to which the dimensions can be differentiated.

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4. Preparation of scales to assess the team dimensions. For initial research studies, three ratings are proposed: occurrence, time of occurrence, and reactivity.

The second phase of this effort would involve a field research investigation to determine whether the instrument can be used to assess team performance. Site visits would be made to four operating teams (both tactical and strategic) or exercises. The prototype team functions taxonomy scales would be used to assess the performance of the teams. Air Force personnel will be trained in the use of the instruments and data would be obtained from both contractors and Air Force raters. Questions to be addressed are:

- Are the dimensions clear and distinct?

- Are the behaviors to be scored observable or are data on them obtainable?

- Can the judgments required by the scales be made by both contractor and Air Force raters?

- Are the data from the instrument quantifiable? Can a score or index of performance be derived?

- Are the rating scales applicable to different kinds of C^2 teams?

Two methods can be used to provide data to answer these questions. First, Air Force and contractor raters can provide an evaluation of their rating task. They can judge: the ease of using the scales, whether it was clear which behaviors were to be assessed, the extent to which each team could be evaluated using the scales, and the degree to which important behaviors were captured by the rating process. Second, the ratings can be analyzed. Statistical analysis can determine the similarity of ratings of Air Force personnel and contractors, and the extent to which the dimension ratings are distinct.

Results of this study can be used to revise and improve the instrument, and to help clarify the knowledge and training needed to use it. For example, if Air Force personnel find it difficult to use the scales, then more training is needed.

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Reliability estimation. The technical adequacy of the assessment instrument also needs to be determined. First, a reliability study should be conducted. Reliability is the proportion of observed score variance that is non-error variance (Cronbach, 1970). In this research, the most relevant type of reliability to study is interrater reliability; here, the error variance is due to differences in judgment. Judgment differences may be due to lack of clarity in the instructions, unstandardized ratings, or imprecise specification of what the assessor should observe or evaluate. To determine impact of these potential sources of error on the ratings, several judges need to evaluate C^2 teams independently, using the instrument. Both contractor and Air Force rateers should participate in this study. Inter-rater reliability analysis can be used to determine the similarity in ratings of the judges. If the reliability estimates are low, revisions in the instrument should be considered, including: clarifying the definitions of instruments, making the judgment more standardized, or specifying the behaviors covered by the dimensions.

Validation of the instrument. The next step in the instrument development is to determine its validity and its usefulness as a diagnostic and prescriptive tool. Validity is the extent to which inferences drawn using the instrument are justified and supported by evidence (American Psychological Association, Division of Industrial-Organizational Psychology, 1980). This instrument was developed to assess team dimensions which are associated with C^2 effectiveness. Validity will be assessed by the extent to which judgments of the dimensions using the instrument are related to measures of C^2 effectiveness.

In order to determine the validity of the instrument, first a measure of C^2 team effectiveness is needed. Such a measure may be based on quantitative data regarding performance (e.g., kill ratios, number of successful sorties) or judgments by exercise staff. (These judgments would be made using a set of scales reflecting overall team performance.) A firm set of guidelines and measures needs to be established a priori to serve as criteria, and there needs to be strong evidence that

the criteria do, in fact, reflect some measure of overall performance (e.g., consensus of subject-matter experts).

A C^2 team's effectiveness would be determined using this measure. Then the team would be independently evaluated using the team dimensions rating scales. The validity of the scales is the extent to which scale scores correlate with the scores on the effectiveness measure.

After determining the validity of the instrument, research needs to be conducted on its generalizability and the degree to which it is useful for different C^2 teams in different scenarios. Studying the instrument's generalizability would involve repeating the prior research steps under varying conditions. Different teams, and teams exercising in diverse scenarios, would be assessed. Evaluations would be made of the instrument's technical adequacy and ease of use. The research designs described previously, concerning field testing, reliability, and validity, would be used again.

After these basic steps are completed and it has been demonstrated that the model is actually useful in team assessment, other important research issues concerning the use of the assessment method could then be addressed. Several possible issues are listed below.

- What is the utility of the output of the model to training developers? Is it useful as a diagnostic tool in identifying the areas where training needs strengthening?

- Where in the training cycle does assessment work best? Can evaluation using the taxonomic model be implemented at any time during training? Are there differences in how the model should be used or interpreted depending upon where in the training cycle it is used?

- How do the results of the evaluation using the taxonomic model relate to individual performance? What is the relationship between the diagnosis of team performance deficits and the need for individual improvement?

- Does the instrument identify problems that are significant? If these problems are remediated, is the team more effective?

Project Summary

This study was conducted in order to improve the methods currently used to assess tactical C^2 teams. After reading the literature on C^2 teams and interviewing Air Force personnel about C^2 team assessment, it was concluded that there was no formal, systematic evaluation of tactical C^2 teams. Instead, the outcomes of C^2 performance are assessed. These assessments rarely consider the team aspects of C^2 performance and are not standardized.

As a foundation on which to develop an improved assessment method, a model of team effectiveness was prepared. There are three aspects of effectiveness in the model: productivity (outcomes or products), operational readiness (member abilities and team functions), and motivation (energizing of behavior). This study focused on one aspect of operational readiness: team functions. In previous ARRO studies (Nieva et al., 1978; Shiflett et al., 1982), a taxonomy of team dimensions was prepared and rating scales measuring the dimensions were developed. During observations of training exercises in which tactical C^2 teams participated, the usefulness of the taxonomy and the rating scales was studied.

It was found that all the dimensions in the taxonomy could be observed and that two new dimensions should be added. It was also determined that the rating scales should be modified for assessing tactical C^2 teams. This paper includes recommendations for revising the scales and for assessing their usefulness and technical adequacy.

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APPENDIX A

Team Function Rating Scales Used in the
Shiflett, Eisner, Price, & Schemmer (1982) Study

NOTE: Instructions assume a laboratory experimental setting as con-
ducted by Shiflett et al. (1982). Instructions would be adjusted
to the appropriate C^2 setting, as necessary. For example, in a
CRC, episodes begin when tracks first appear on a scope, and end
when the track has been dealt with. Instruction might then read,
"Was the function present during the episode just observed?"
This instruction could be followed by a definition of the dimen-
sion and a scale which includes: "Present," "Absent."

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TEAM FUNCTION RATING SCALES

I. ORIENTATION

Was the ORIENTATION function present in the videotaped segment you just viewed?

YES _____   NO _____

If "yes," rate the following four ORIENTATION scales (IA, IB, IC, ID). If "no," go on to function II.

IA. Rate the extent to which you perceived the ORIENTATION function occurring in the videotaped segment.

---

7 ————— The team activities were <u>exclusively</u> concerned with orientation.

6 ————

5 ————

4 ———— The team activities were <u>moderately</u> concerned with orientation.

3 ————

2 ————

1 ————— The team activities included a <u>small amount</u> of orientation.

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I. ORIENTATION

(Number of Personnel)

IB. Rate the extent to which you perceived the ORIENTATION function occurring in the videotaped segment by indicating the number of team personnel involved in <u>orientation</u>. (Caution: Remember that the scale values represent levels, not actual numbers of men involved.)

7 — The <u>full complement</u> of men was involved in the orienting information exchange.

6 —

5 —

4 — <u>Approximately half</u> of the team was involved in the orienting information exchange.

3 —

2 —

1 — The orienting information exchange occurred primarily <u>between two team members.</u>
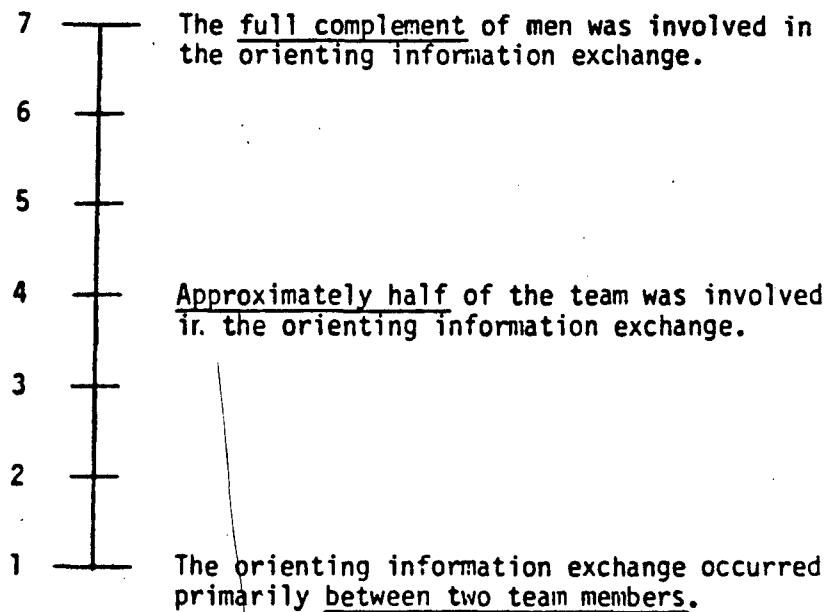
I. ORIENTATION

(Duration of Orientation)

IC. Rate the extent to which you perceived the ORIENTATION function occurring in the videotaped segment by indicating the duration of time devoted to orientation.

---

7 — The _entire_ duration of videotaped activity appeared devoted to orientation.

6 —

5 —

4 — _Approximately half_ of the videotaped activity appeared devoted to orientation.

3 —

2 —

1 — A _very small amount_ of videotaped activity appeared related to orientation.
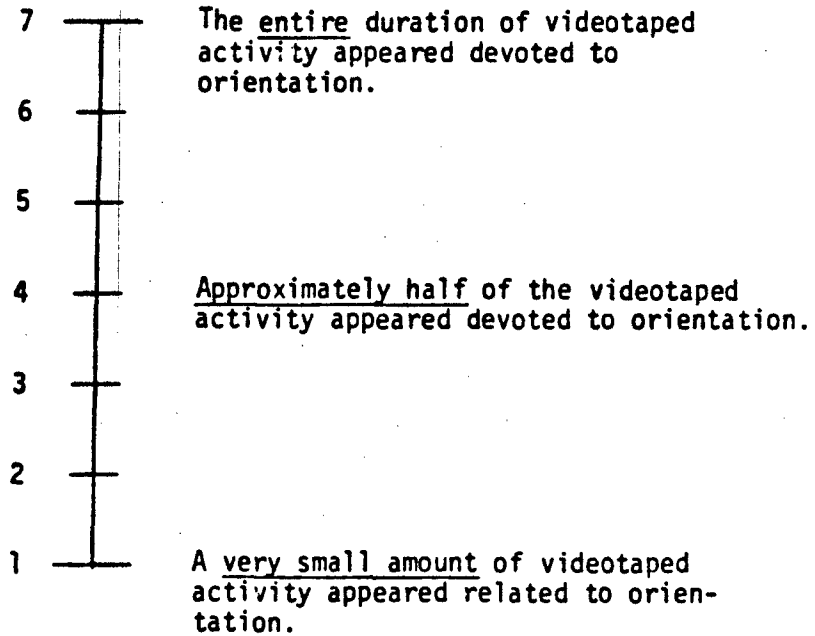
I. ORIENTATION

(Types of Orientation)

> ID. Rate the extent to which you perceived the ORIENTATION
> function occurring in the videotaped segment by indi-
> cating the number of types of information exchanged.
> Types of information may include reference to tasks,
> goals, procedures, task priorities, team members, equip-
> ment, environment, or operational constraints, as well
> as feedback.

```
7 ──┬──   The information exchanged included
    │     all types of information.
    │
6 ──┼──
    │
    │
5 ──┼──
    │
    │
4 ──┼──   The information exchanged concerned
    │     several types of information.
    │
3 ──┼──
    │
    │
2 ──┼──
    │
    │
1 ──┴──   The information exchanged basically
          concerned one type of information.
```

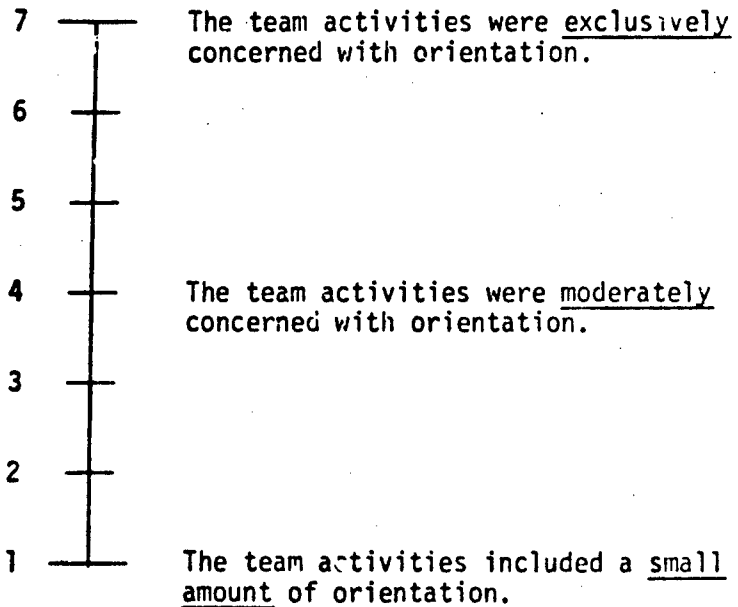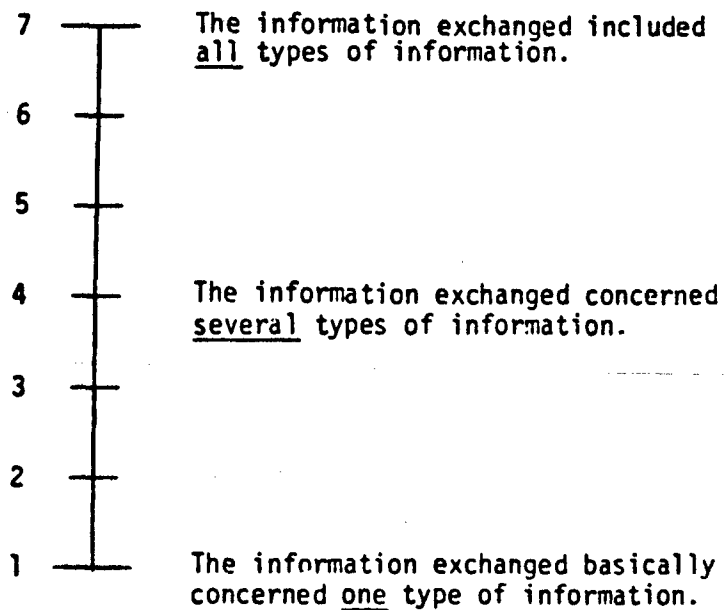## II. RESOURCE DISTRIBUTION/LOAD BALANCING

Was the RESOURCE DISTRIBUTION/LOAD BALANCING function present in the videotaped segment you just viewed?

YES _____   NO _____

If "yes," rate the following three RESOURCE DISTRI-
BUTION/LOAD BALANCING scales (IIA, IIB, IIC). If
"no," go on to function III.

IIA. Rate the extent to which you perceived the RESOURCE
DISTRIBUTION/LOAD BALANCING function occurring in the
videotaped segment.

---

7 ——— The team activities were _exclusively_
concerned with resource adjustment/
load balancing.

6 ——

5 ——

4 —— The team activities were _moderately_
concerned with resource adjustment/
load balancing.

3 ——

2 ——

1 ——— The team activities were only _slightly_
concerned with resource adjustment/
load balancing.
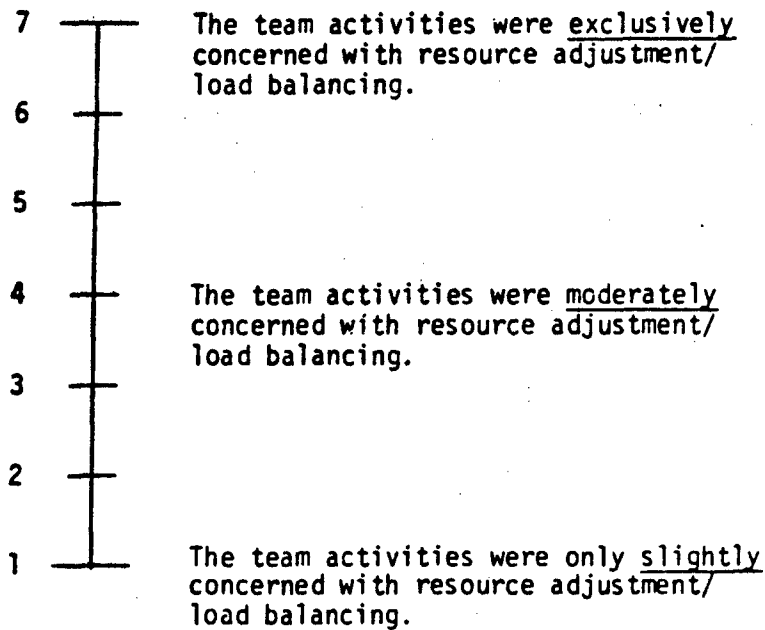
II. RESOURCE DISTRIBUTION/LOAD BALANCING

(Number of Personnel/Amount of Equipment)

> IIB. Rate the extent to which you perceived RESOURCE DIS-
> TRIBUTION/LOAD BALANCING by indicating the number of
> personnel/amount of equipment included in the resource
> adjustment.

7 — All of the team personnel shifted
their efforts from one task to
another to further the mission; or
6 — all of the team's equipment was re-
distributed for the team effort.

5 —

4 — Approximately half of the men (or
equipment) was redistributed for
the team effort.

3 —

2 —

1 — Almost no one shifted his efforts
to respond to a local imbalance; or
only a minor piece of equipment needed
to be redistributed for the team
effort.

II. RESOURCE DISTRIBUTION/LOAD BALANCING

(Interchangeability of Men or Equipment)

> IIC. Rate the extent to which you perceived RESOURCE DIS-
> TRIBUTION/LOAD BALANCING by indicating the degree to
> which persons or supplies were interchangeable and
> did not disrupt the team effort.

7 — The team effort proceeded undis-
rupted when resources were re-
allocated. (Resource adjustme..
6 — was a normal part of the task
requirement.)

5 —

4 — The team effort underwent moderate
disruption when resources were
reallocated.
3 —

2 —

1 — Team activities were severely dis-
rupted when resources were reallo-
cated.

III. ACTIVITY PACING

Was the ACTIVITY PACING function present in the videotaped segment you just viewed?

YES _____   NO _____
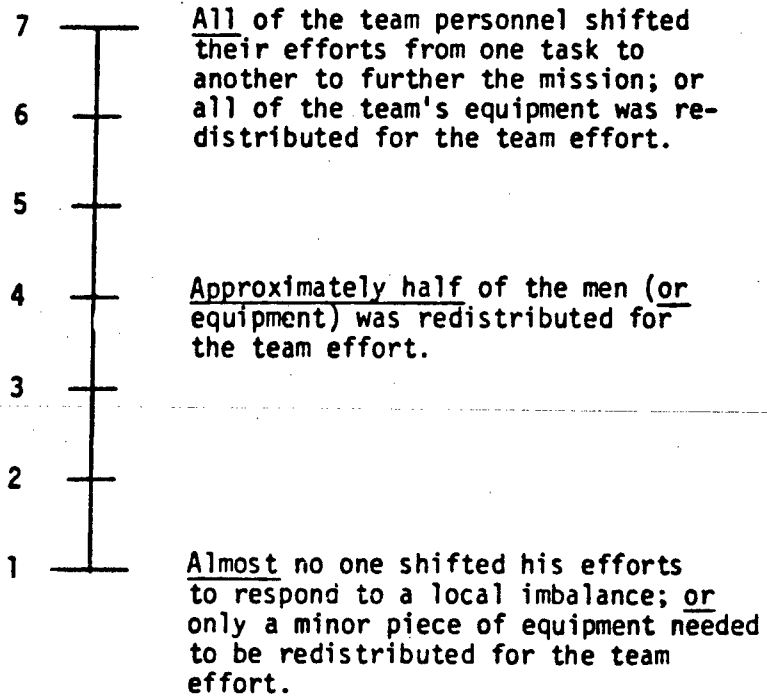
If "yes," rate the following three ACTIVITY PACING scales (IIIA, IIIB, IIIC). If "no," go on to function IV.

IIIA. Rate the extent to which you perceived the ACTIVITY PACING function occurring in the videotaped segment.

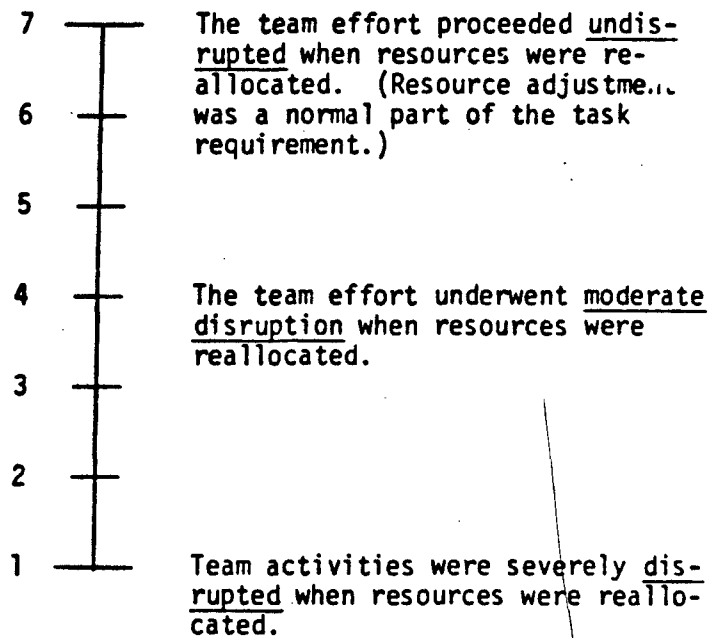7 ——— The team activities were characterized by a <u>great deal</u> of activity pacing.

6 —

5 —

4 — The team activities were characterized by a <u>moderate amount</u> of activity pacing.

3 —

2 —

1 ——— The team activities were characterized by <u>low levels</u> of activity pacing.
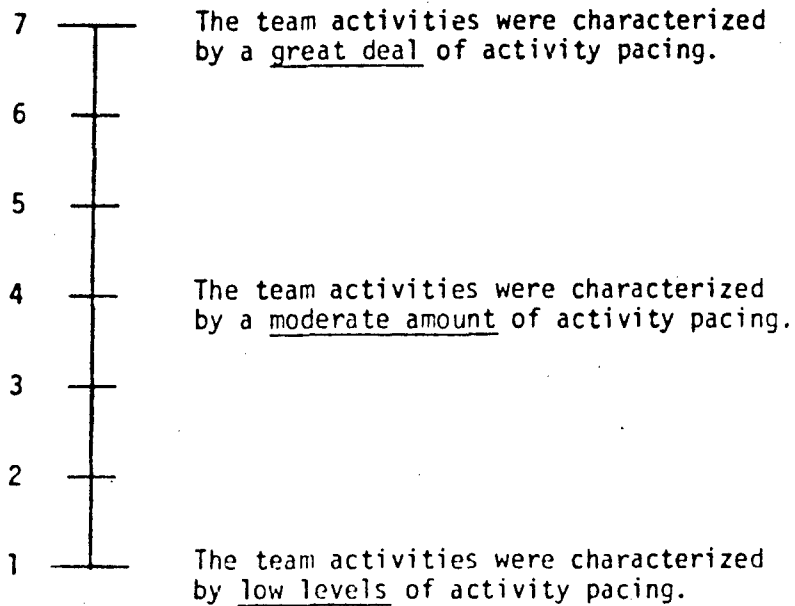
III.   ACTIVITY PACING

(Communications about Speed/Timing Changes)

IIIB.   Rate the extent to which you perceived the ACTIVITY
        PACING function occurring in the videotaped segment
        by indicating the number of communications about
        starting or stopping activities, or about changing
        the speed of activities.

---

7 —   There were <u>many</u> communications
       regarding speed changes, or
       starting or stopping activities.

6 —

5 —

4 —   There were <u>several</u> communications
       regarding speed changes, or be-
       ginning or stopping activities.

3 —

2 —

1 —   There were <u>no</u> communications
       regarding speed changes, or
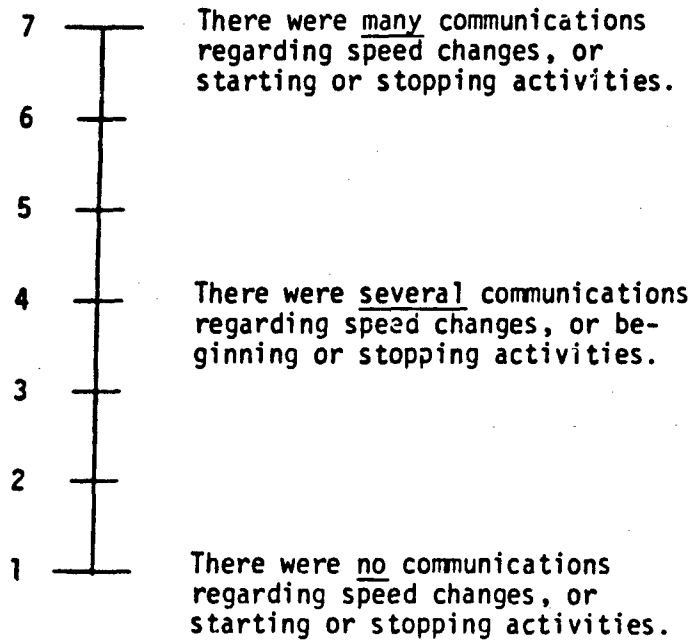   starting or stopping activities.

III. ACTIVITY PACING

(Visible Speed/Timing Changes)

> IIIC. Rate the extent to which you perceived the ACTIVITY
> PACING function occurring in the videotaped segment
> by indicating the extent to which there were visible
> speed or changes exhibited by the team.

7 — There was a <u>great deal</u> of change in the
speed of the activities.

6

5

4 — There was a <u>moderate</u> amount of change
in the speed of the activities.

3

2

1 — There was almost <u>no</u> change in the
speed of activities.
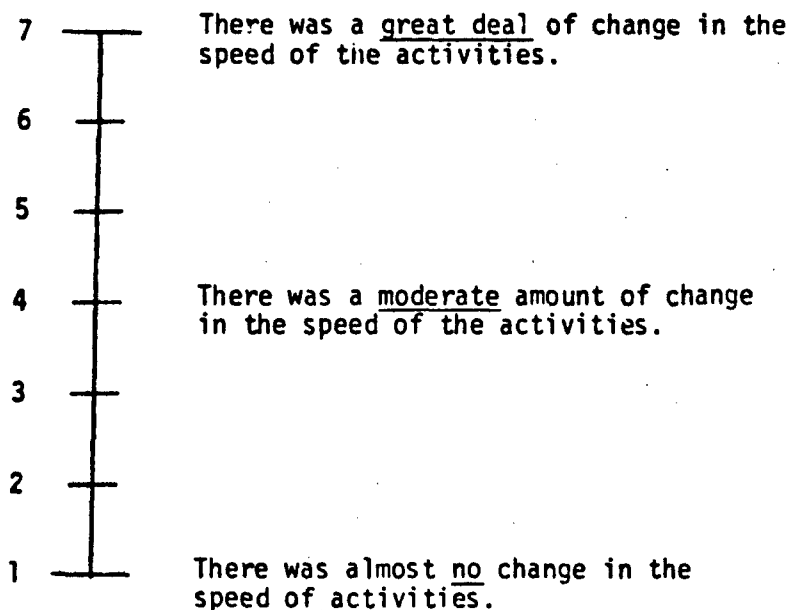
IV. RESPONSE COORDINATION

Was the RESPONSE COORDINATION function present in the video-taped segment you just viewed?

YES _____   NO _____

If "yes," rate the following four RESPONSE COORDI-NATION scales (IVA, IVB, IVC, IVD). If "no," you may stop and wait for the next videotaped segment.

IVA. Rate the extent to which you perceived the RESPONSE
      COORDINATION function occurring in the videotaped
      segment.

---

7 ——— The team activities demonstrated a <u>high</u> degree of response coordination.

6 ——

5 ——

4 —— The team activities demonstrated a <u>moderate degree</u> of response coordi-nation.

3 ——

2 ——

1 ——— The team activities demonstrated a <u>low degree</u> of response coordination.

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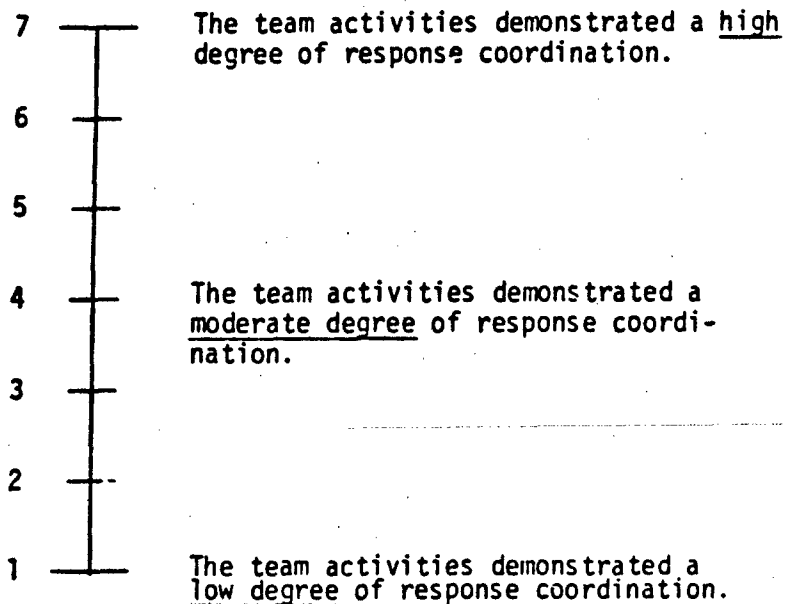
IV. RESPONSE COORDINATION

(Involvement of Team)

> IVB. Rate the extent to which you perceived the RESPONSE
> COORDINATION function occurring in the videotaped seg-
> ment by indicating the degree to which the whole team
> was involved in the coordination effort.

7 —— The entire team was involved in the
coordination activities.

6 —

5 —

4 — About one-half of the team was in-
volved in the coordination activities.

3 —

2 —

1 —— Only a small part of the team was in-
volved in the coordination of the
activities.
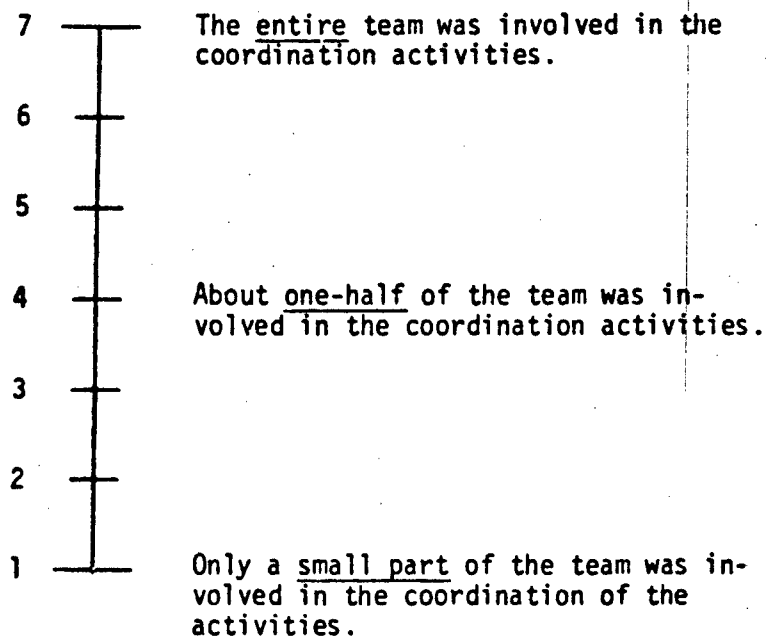
IV. RESPONSE COORDINATION
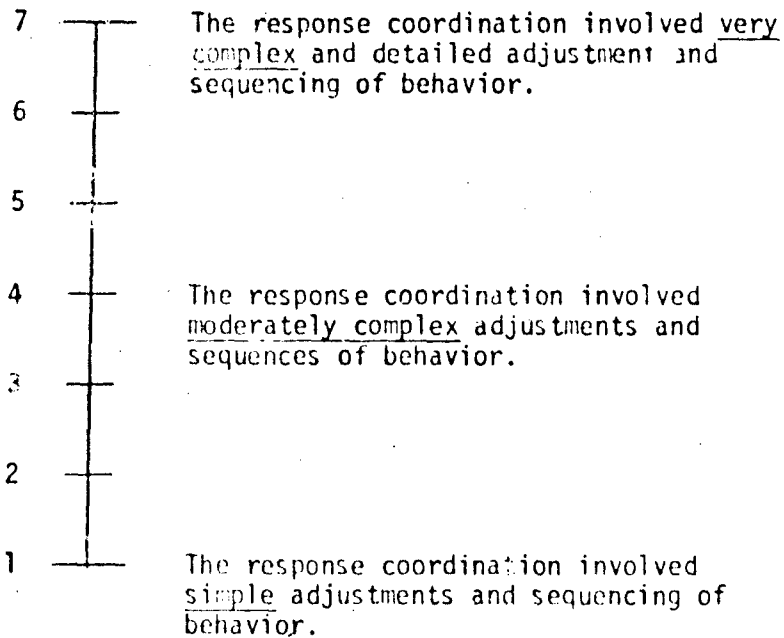
(Complexity of Coordination)

> IVC. Rate the extent to which you perceived the RESPONSE
> COORDINATION function occurring in the videotaped seg-
> ment by indicating the degree to which the team coordi-
> nation efforts occurred in a complex and detailed manner,
> requiring careful and continuous monitoring of other
> team member activities.

7 — The response coordination involved very
complex and detailed adjustment and
sequencing of behavior.

6

5

4 — The response coordination involved
moderately complex adjustments and
sequences of behavior.

3

2

1 — The response coordination involved
simple adjustments and sequencing of
behavior.

IV. RESPONSE COORDINATION

(Similarity/Dissimilarity of Activity)
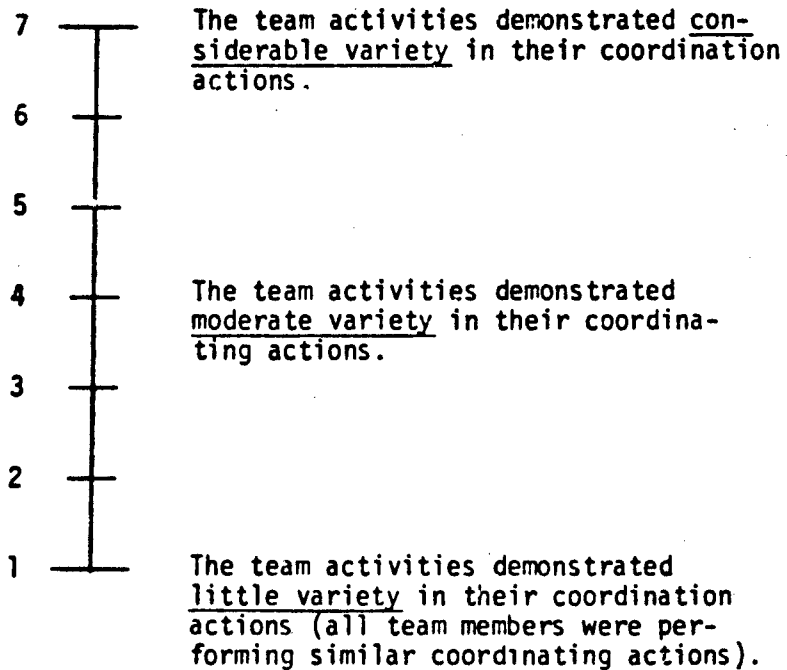
IVD. Rate the extent to which you perceived RESPONSE COORDI-
NATION occurring in the videotaped segment by including
the degree to which the response coordination involved
similar activities from team members or dissimilar acti-
vities.

7 — The team activities demonstrated con-
siderable variety in their coordination
actions.

6 —

5 —

4 — The team activities demonstrated
moderate variety in their coordina-
ting actions.

3 —

2 —

1 — The team activities demonstrated
little variety in their coordination
actions (all team members were per-
forming similar coordinating actions).

APPENDIX B

Interview Questions Used for the C^2 Operations Staff

1. What is the major responsibility of this team?

2. Who are the members of this team? What does each member do?

3. In order to develop or revise an evaluation tool, we first need to understand the team and its members. I would like to discuss the critical tasks performed by each team member. Tasks are critical if, when they are not performed adequately, serious consequences result. For each team member, what tasks could lead to serious consequences if not performed adequately?

4. What tasks are often not performed properly? For each team member, what are the tasks that are often inadequately carried out?

5. We have discussed each team member. Now I would like to talk about tasks performed by the team as a whole or by several members together. Such tasks involve interaction between team members and coordination of activities. What team tasks are linked to important outcomes or products?

6. What team tasks have serious consequences if not performed adequately?

7. For the team tasks you have mentioned as critical, how much flexibility is allowed in the manner and sequence in which the tasks are performed (i.e., are there strict operational procedures that must be followed)?

8. In research on non-military teams, the following team factors have been identified as important (show respondent list of variables in Table 1). Let us discuss whether these factors are important in C^2 teams and just where they apply.

APPENDIX C

Interview Questions Used for the Evaluation Staff

1. Let us discuss the evaluation of this team. What is your role in evaluation?

2. How is the performance of personnel in this team evaluated?

3. Is the evaluation standardized? If not, who plans it? How is it planned? What documentation exists to guide the planning process?

4. Is diagnostic information/feedback provided to team members about their performance? Are there rewards for superior performance and repercussions for inadequate performance for team members? For their commander?

5. Who uses the results of the evaluation? How are they used?

6. What are the advantages of each method of evaluation? Weaknesses? How can the evaluation be improved?

PROTOTYPE INSTRUCTIONS AND ASSESSMENT FORM
FOR MEASURING TEAM FUNCTIONS

Instructions

Make a mark each time a communication serves a team function.
Place the mark in the columns on a minute-by-minute basis. Mark the I
column if the individual _initiated_ the action without any other inter-
personal contact. Mark the R column if the individual performed the
function in _response_ to an action by another team member.

Use a separate observation sheet or set of forms for each situation
or episode. For example, the complete cycle of observing and identify-
ing unknown tracks through the disposing of them, either by identifica-
tion as friendly or destruction if hostile, represents a complete
episode for a CRC. For the Weapons Team, however, the cycle begins with
being assigned the task of intercepting a track already identified as
hostile or unknown.

Definitions of each function along with various examples are
attached for reference.

TEAM FUNCTION RATING INSTRUMENT

MINUTE / Function	1		2		3		4		5		6		7		8		9		10		11		12	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
Orientation																								
Resource Adjustment																								
Activity Pacing																								
Response Coordination																								
System Monitoring (Error Detection)																								
Maintenance of Procedure																								

Personnel being observed/position

Begin time _____

End time _____

Situation _____

_____ / _____

_____ / _____

_____ / _____

_____ / _____

NOTES:

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DEFINITIONS AND EXAMPLES OF FUNCTIONS

I. ORIENTATION

ORIENTATION concerns the extent to which orienting information is exchanged among team members. ORIENTATION provides facts. It does not command or initiate action. The information exchange may concern work, tasks, goals, procedures, task priorities, team members, equipment, the environment, or operational constraints. Feedback about previous performance can also qualify as ORIENTATION. ORIENTATION always occurs in the form of a communication. Orienting information differs from non-orienting information in that orienting information is always task related, while non-orienting information is extraneous or irrelevant to the task.

The extent to which teams exhibit the ORIENTATION function is related to the number of team members participating in the orientation, the length of the orientation, and the type of information exchanged.

Examples of Orienting Information:

1. "Mission accomplished."

2. "We have seven unidentified tracks at 180 degrees."

3. "I have four missiles left."

Non-Orienting Information:

1. "The sun is shining."
    (Spoken in the course of normal conversation, this would be non-orienting information. However, in another situation where the sun's shining is critical to task performance, such as photographing into the sun, this could become orienting information. The context in which the statement is made, therefore, must be considered in distinguishing between orienting and non-orienting information.)

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II. RESOURCE DISTRIBUTION/LOAD BALANCING

RESOURCE DISTRIBUTION or LOAD BALANCING concerns the degree to which team members adjust their activities to redistribute their personnel resources, equipment resources, or information resources. RESOURCE DISTRIBUTION or LOAD BALANCING occurs when team members recognize or respond to a perceived imbalance in their team resources.

RESOURCE DISTRIBUTION may occur as either a communication (e.g., a command or request for additional manpower or equipment) or a behavioral action. As a communication, it is distinguishable from ORIENTATION in that the communication contains a definite implication or request for action rather than being simply a statement of fact. When RESOURCE DISTRIBUTION occurs as a behavioral action, the adjustment is always a team effort rather than an individual effort; one person adjusting a piece of equipment on his/her own initiative, as a normal part of the job, does not constitute RESOURCE DISTRIBUTION.

The degree of RESOURCE DISTRIBUTION may be judged by noting the amount of communication regarding redistribution, the number of personnel or amount of equipment that is redistributed, the interchangeability or adaptability of the personnel or equipment that is redistributed, and how the resource allocation is initiated.

Communication Examples:
1. "Help me out!"
2. "Blue Eagle, turn left 180°, and prepare to intercept unidentified aircraft."

Behavioral Examples:
1. Two firefighters coming over to help a third firefighter handling a hose with high pressure water.
2. Dishwasher comes out to clear off tables during a busy period.

III. ACTIVITY PACING

ACTIVITY PACING is the extent to which a team changes the timing or speed of its tasks to facilitate the team mission. Speed and timing changes refer to the efforts of a team to increase, decrease, or maintain its pace on a task. These efforts can involve changing the pace of the entire team or adjusting the pace of part of the team in relation to other team activities.

ACTIVITY PACING may occur as either a behavioral action (e.g., the team slows down the pace of one task while increasing the speed of another) or a communication. The communication is often in the form of a command or request intended to initiate, direct, or control the timing or speed of events; it differs from ORIENTATION in that the communication contains a definite implication for action rather than being simply a statement of fact.

ACTIVITY PACING is distinguished from LOAD BALANCING in that it involves no change in personnel or equipment distribution; it is concerned simply with timing and speed.

Communication Examples:
1. "Let's get that status board up to date."
2. "Slow down, you're running away from your target."
3. "Take your time."
4. "Start when I tell you to."

Behavioral Examples:
1. Sandwich maker in snack bar working faster when there is a long line at the counter.
2. Two firefighters start walking, then break into a run to come over to help a third firefighter with a high pressure hose.
3. Any obvious change in the speed of an action in response to communication or change in the situation.

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IV. RESPONSE COORDINATION

RESPONSE COORDINATION refers to the degree to wh
coordinate their responses in relation to a piece of
example, in maneuvering a heavy desk, team memb.
sate for, or adjust to the actions of others who
the desk. The degree of response coordination is thus related to the
requirement for coordination, the complexity of the adjusting actions,
and the extent to which the adjusting actions need to be ordered (occur
simultaneously or in sequence) as opposed to occurring spontaneously
without reference to order.

RESPONSE COORDINATION almost always occurs in the form of a visible
behavior. Since RESOURCE DISTRIBUTION and ACTIVITY PACING activities
may also involve some degree of RESPONSE COORDINATION, use the latter
function only when RESOURCE DISTRIBUTION and ACTIVITY PACING are not
present, or when they are clearly serving the more complex requirement
of RESPONSE COORDINATION.

Examples of Response Coordination:
1. Two men chopping down a tree, alternating their axe chops into
   the same cut.
2. A "bucket brigade" at a fire where a bucket is passed along a
   chain of people to the fire.

Communication Examples:
1. "Don't fire until I give you the word."
2. "Squadron flying in formation."
3. "When I get the updated ATO, you get the intelligence reports."

SYSTEM MONITORING has the purpose of ERROR DETECTION or PROBLEM ETECTION. It refers to human actions designed to determine whether ther team members are doing what they are supposed to and at the right ime. The detection of a problem or error will usually result in the erformance of one of the other functions in order to correct the detected problem. If things are "OK", then feedback to that effect may occur.

SYSTEM MONITORING is usually evidenced in asking of questions. Note that the purpose of the question must be to assess the state of current operations in some way in order to be SYSTEM MONITORING. A question simply to obtain some information (even if task-relevant) would be an example of ORIENTATION rather than SYSTEM MONITORING.

System monitoring will usually be in the form of questions:
1. "Where are you?"
2. "What's your fuel status?"
3. "Is this track identifier correct?"
4. "Have you ID'd the unknown at 2 o'clock yet?"
5. "Is your scope working?"

VI. PROCEDURE MAINTENANCE

PROCEDURE MAINTENANCE is designed to make sure everyone is following proper procedures, which are usually pre-determined by equipment configuration and standard operating procedures. In some emergent situations, an ad hoc procedure may have been mandated by the commander and PROCEDURE MAINTENANCE would reinforce the proper functioning of the new and relatively unfamiliar procedures.

You may need to know correct procedure in order to distinguish this function from others. For example, "Call the WAO first" will be a PROCEDURE MAINTENANCE function if it is said in response to an error in established procedures, but it may be RESPONSE COORDINATION if said simply to correct some coordination problems.

<u>Examples of Procedure Maintenance</u>:
1. "Call the WAO first."
2. "Turn your radio on."
3. "Stay in formation."
4. "Get that information to surveillance."

IDENTIFYING FUNCTIONS BY PURPOSE/GOAL SERVED

In order to determine the presence of a particular function, it is often useful to ask what purpose or goal the behavior is serving. Remember that at least two individuals must be involved for a function to occur.

Orientation

The purpose here is to provide information that somehow relates to or maintains team activities either (a) by providing feedback about performance or (b) by telling other team members about the situation they must work in.

Resource Distribution/Load Balancing

The purpose here is to adjust resources--either equipment, materials, or manpower.

Activity Pacing

The purpose here is to alter or maintain the speed of an operation (a) to keep team members at the same approximate pace or (b) to get team members into proper pace with respect to one another.

Response Coordination

The purpose here is to accomplish a task that could not be performed by one individual, in a coordinated, synchronous, harmonizing manner.

System Monitoring

The purpose here is to make sure that all operating procedures are occurring smoothly and effectively, by checking for errors and omissions.

Procedure Maintenance

The purpose here is to assure that the system operates properly by making sure that all operations and procedures occur properly and at the proper time.

EXAMPLE OF HOW THE SAME OR SIMILAR BEHAVIOR
CAN SERVE DIFFERENT FUNCTIONS

The pit crew of a race car driver sends information to the driver by means of easily visible signals.

- One signal might tell the driver to increase or decrease his speed (Activity Pacing).

- One signal might tell him how many laps until tne next pit stop, or the condition of a tire, etc. (Orientation).

- One signal might tell him to come in for a pit stop to adjust equipment or to change drivers (Load Balancing).

- The actual pit operations can simultaneously include changing the tires, gassing up, giving water and food to the driver, and performing other adjustments to the car (Response Coordination).

Although the pace of this activity is very high, once the action is underway, Activity Pacing is not an element unless there are changes or attempts at changes in the speed of operations.