

Research Note 84-111



COMMAND GROUP BEHAVIORS: THEIR IDENTIFICATION,
QUANTIFICATION, AND IMPACT ON COLLECTIVE OUTPUT
IN AUTOMATED AND NON-AUTOMATED ENVIRONMENTS

AD-A144 071

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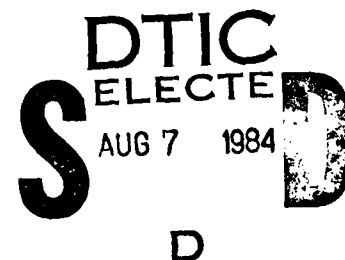
U. S. Army

Research Institute for the Behavioral and Social Sciences

July 1984

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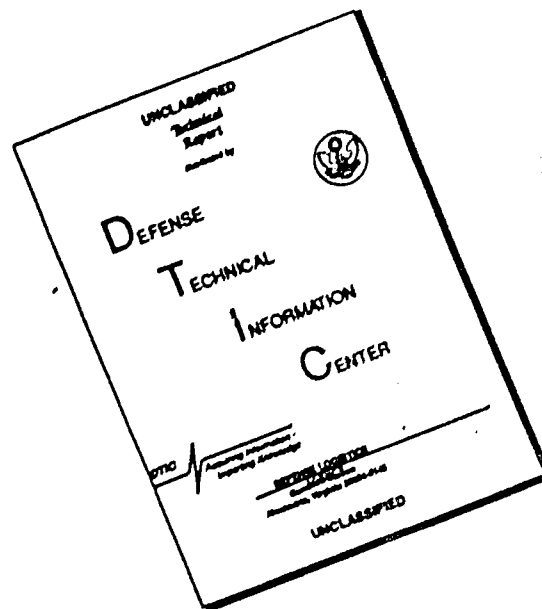
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
Research Note 84-111	AIA - - 171	
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
Command Group Behaviors: Their Identification, Quantification, and Impact on Collective Output in Automated and Non-Automated Environments		Annual Technical Report 1 Apr 1982-31 March 1983
6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
Charles F. Carter, Jr., Daniel C. Lockhart, and Marcus S. Patton		MDA903-81-C-0254
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS
Science Applications, Inc. 424 Delaware, Suite C3 Leavenworth, Kansas 66048		2Q162717A790
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
US Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Ave., Alexandria, VA 22333		July 1984
13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES
US Army Research Institute Field Unit Post Office Box 3122 Fort Leavenworth, KS 66027		222
14. SECURITY CLASS. (of this report)		15. SECURITY CLASS. (of this report)
Unclassified		Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		X
16. DISTRIBUTION STATEMENT (of this Report)		
Approved for public release; distribution unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
X		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Command and control Non-procedural behavior Command group behavior Command group effectiveness Individual behavior Combat effectiveness Team behavior Behavior evaluation methodology <u>Combined Arms Tactical Training Simulator (CATTS)</u>		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
(attached sheet)		

Unclassified

20. This report summarizes first year efforts and provides detailed results of the second year research efforts (of a three year project) to relate battalion commander and staff behavior to command group effectiveness. An initial methodology for relating behavior to effectiveness was developed; video and audio recordings of battalion command group participation in computer-assisted battle simulations were produced; recorded data were classified by military experts to assist in behavior analysis; and analyses of the data using the initial methodology were performed. Analyses of the data yielded inconclusive statistical correlations and judgmental evaluations between command group behavior and group effectiveness using the methodology. Changes to the initial methodology as well as improvements to the research laboratory are discussed.

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SECTION 1
INTRODUCTION

Science Applications, Inc., (SAI) is under contract (MDA903-81-C-0254) to the Army Research Institute to perform work associated with military command group behaviors; their identification, quantification, and impact on collective output in automated and non-automated environments. Objective 1 of the contract, a major task of SAI's effort, is being performed in direct support of the ARI Field Unit, Fort Leavenworth, Kansas. This report documents the performance and results of the work accomplished during the second year of effort on Objective 1. An introduction is presented in this section to afford the reader an understanding of tasking and overall performance of Objective 1 through the second contract year. An initial methodology for analyzing command group behavior, is presented in Section 2, the results of the application of the methodology are presented in Section 3, and conclusions and recommendations are presented in Section 4.

This Technical Report for the second contract year satisfies Contract Line Item Numbers 0002AC (draft) and 0002AD (final).

1.1 PURPOSE

The purpose of Objective 1 is to develop and apply a methodology for differentiating the non-procedural individual and multi-individual behaviors from the team or synergistic behaviors in battalion command groups and determining their respective contribution to command group effectiveness.

1.2 RESEARCH NEED

It is widely recognized that modern warfare will be conducted in dynamic and unpredictable environments never before experienced by military decision makers. The rate, complexity, dimensions, uncertainty, and risks associated with warfare will be exacerbated by advancements in all fields of technology directly and indirectly applicable to the conduct of war. Correspondingly, there is a pressing need to examine the behavior of military decision-making groups involved in the acquisition, processing, and utilization of information in efficient and effective force management. Effective command and control of military forces and resources requires detailed knowledge and

understanding of how these command groups operate, make decisions, and apply resources to successfully prosecute modern military operations.

It is known from past practice of the art of war that there is a continuing requirement to develop an organizational competence to exercise military command and control. This competence must be developed in individuals and groups of individuals performing explicitly assigned staff and command functions as well as in aggregations of individuals performing highly synergistic team processes so vital to military force management and success in battle. It is also known from past experience and research that there are many staff activities, individual and team, for which specific procedures can be prescribed and exercised and which require minimal mental initiatives by participants to perform efficiently. Concomitantly, a wide range of non-procedural activities are perceived which are necessary to effectively control and direct military operations, and these activities are principally associated with mental and behavioral processes on the part of individuals and teams of individuals tasked to exercise military command and control. These non-procedural activities are heavily mission-dependent as to the extent of their application and, based on assigned mission, include such behaviors as:

- o Perception of the need for information to successfully prosecute the mission.
- o Active seeking of accurate, timely, and complete information to reduce the

uncertainty and risk relating to force management.

- o Receiving, assimilating, integrating, and coordinating relevant information so as to properly influence decisions and actions to be taken.
- o Assessing the capability to act or react and evaluating alternatives for such actions.
- o Solving the problems associated with force management in mission-associated operations and selecting from alternatives available the course of action to be prosecuted.
- o Communicating in a timely manner the decision and orders to others who must act or react to successfully accomplish the mission.
- o Monitoring, coordinating, and supervising the execution of the orders, adjusting to the evolving situation as necessary.
- o Continuously assessing the impact of command group performance on combat effectiveness and optimizing that performance at every opportunity.

Ascertaining the dimensions of effective individual and team performance of command groups in operational situations will contribute significantly to a more complete understanding of military command and control. Greater knowledge of these dimensions will facilitate the development of effective command and control training procedures and systems as well as support the establishment of functional requirements specifications for battlefield automation and its configuration to support the tactical command and control process.

1.3 FIRST YEAR ACHIEVEMENTS

The first contract year was devoted to performance of five main tasks as precursors to the development of a detailed methodology for identifying and evaluating military command group behavior. The five main tasks are identified and briefly discussed in the following subparagraphs. The discussions support a better understanding of overall contract performance and place in proper context the work performed during the second contract year.

1.3.1 Review and Analysis of Video and Audio Tapes

The review and analysis of video and audio tapes recorded during the conduct of command group exercises using the Combined Arms Tactical Training Simulator (CATTS)

required that initial project efforts be concentrated on:

- o An appreciation of Army staff organizational principles, the identification of staff functional roles and relationships, and the documentation of the overall process by which military decision-making takes place within field organizations.
- o The development of a generalized model of the Army information flow and decision-making process.
- o An understanding of CATTS and its utilization as a training and evaluation tool by the Army.
- o A critical appraisal of the CATTS instrumentation system.
- o An evaluation of the quality and quantity of audio and video data which could be recorded using available equipment and systems and which would permit the development and application of a methodology for evaluating command group behavior and effectiveness of command group performance.
- o An appraisal of the complexity and utility of a methodology for evaluating command group effectiveness in decision making.

Completion of this task resulted in conclusions that a generalized methodology for identifying and classifying command group behaviors and for measuring their contribution to command group effectiveness was within the current state of the art; that information derived from CATTS exercises could be used to validate the methodology; and that major improvements in equipment and procedures were needed to enhance the quality and quantity of recorded data before the methodology could be applied to an analysis of command group behavior using CATTS as a laboratory.

1.3.2 Identification of Audio/Visual Modifications and Additions

This task was performed concurrently with the preceding task, and its performance revealed deficiencies in both recording and playback systems which were required to be reduced or eliminated if CATTS were to be used effectively as a laboratory for evaluating command group behavior and effectiveness. Short term and long term improvements (modifications and additions) were recommended to overcome some of the deficiencies in order to acquire data for more effective analysis.

During the first year, most short term improvements were initiated and completed; however, it became necessary that some short term improvements be refined during the second contract year. Long term

improvements, consistent with the analytical methodologies to be employed, were to be integrated into a long range instrumentation plan. The long range plan was to be developed and implemented during the second contract year consistent with available resources.

1.3.3 Design and Development of a Probe System

SAI designed two probe systems consisting of a communications jamming probe and a counterattack probe. The jamming probe was an artificially inserted probe system designed for the purpose of observing and analyzing procedural behaviors on the part of the battalion command group, while the counterattack probe was a naturally-occurring probe system designed for the purpose of observing and analyzing both procedural and non-procedural behaviors of the command group. A limited analysis of the probe data and associated command group behavior occurred during the first contract year; however, the probe systems required refinement during the second contract year in order to be effectively utilized.

1.3.4 Collection of Data from Three Potential Sources

Tasking for the project envisaged the opportunity to collect behavior data from three sources during the first contract year; namely, from participation in CATTS

exercises by Regular Army command groups; by reserve component (USAR and ARNG) command groups; and by command groups constituted on an ad hoc basis. Behavior data were recorded on both audio and video tapes for all command groups which participated in CATTS since project inception in April 1981. The opportunity to collect data from two of the three identified sources was extremely limited during the first contract year. Of 21 battalion command groups participating in CATTS exercises during the first year, 19 were Regular Army groups, one was an ARNG group, and one was an ad hoc group from the Human Engineering Laboratory of Aberdeen Proving Ground. Based upon the limited non-Regular Army command group participation in CATTS exercises during the first year, coupled with limited recording capabilities attributable to insufficient instrumentation, it was summarily deduced that an analysis of Reserve Component and ad hoc battalion-level staffs would contribute little statistically significant results to the analysis of battalion command group behavior.

1.3.5 Development of an Initial Methodology for Behavior Analysis

An expert panel workshop was convened early in the first contract year to address the conceptual and methodological issues of the project. The panel included experts in the fields of decision theory, organizational behavior, applied behavior research methodology, and Army

command and control modeling.

From the expert panel workshop and from the performance of the other tasks assigned for the first contract year, a framework for the formulation of an initial methodology evolved. The developmental efforts undertaken during the first contract year, however, were much more in the nature of a feasibility test and a demonstration of the kinds of analysis which could be employed in overall project performance.

A generalized methodology for differentiating the non-procedural individual and multi-individual behaviors from the team or synergistic behaviors in battalion command groups and for determining their respective contribution to command group effectiveness was developed and applied during the first contract year, but the methods both for differentiating categories of behavior and for analyzing their respective contribution to command group effectiveness suggested the need for refinement during the second year.

1.4 SECOND YEAR TASKS

In the performance of its contractual effort during the second year, SAI concentrated on two principal tasks; first, the continued development and refinement of an initial methodology for analyzing and evaluating command group behavior; and, second, the application of the initial methodology to the analysis of data collected from training

simulations conducted by battalion command groups using the Combined Arms Tactical Training Simulator (CATTS) at Fort Leavenworth, Kansas. Additional tasks assigned by contract modification were (a) the complete and effective instrumentation of the CATTS facility in order to collect video and audio data of sufficient quality and quantity to support behavior analysis of the battalion command groups and (b) the development of a performance feedback package for CATTS player groups. The effective performance of all of the above tasks precluded the development of alternative analytical methodologies and techniques during the second year; therefore, this latter task will be rescheduled for performance during the third contract year.

1.5 RESEARCH PLAN AND PERFORMANCE

In conformance with contract requirements, SAI developed and submitted to the Contracting Officer's Technical Representative (COTR) a research plan for second contract year performance. The major tasks and subtasks of the research plan are depicted in Figure 1-1 and are identified in the subparagraphs which follow. The narrative associated with each task and subtask describes how the tasks were performed. The methodology developed and the specific results achieved by task performance, however, are reserved for presentation in Sections 2 and 3 of this annual Technical Report.

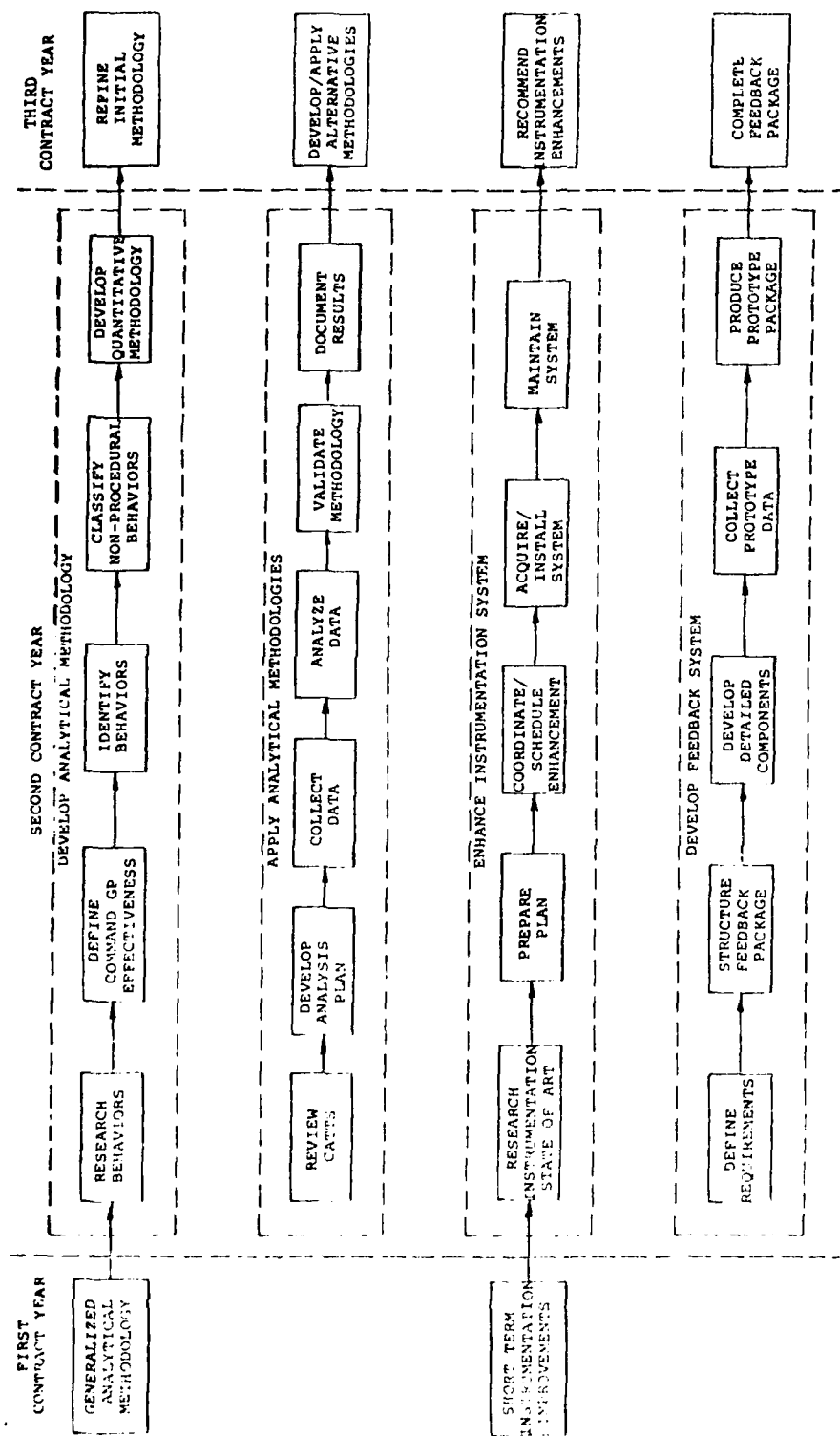


Figure 1-1. FLOWCHART OF SECOND YEAR TASKS

1.5.1 Develop Analytical Methodologies (Task 1)

A major Objective 1 task for the second contract year was to refine and formalize the initial methodology for differentiating the non-procedural individual/multi-individual behaviors from the team or synergistic behaviors in battalion command groups and for determining their respective contribution to command group effectiveness. The required initial methodology has been developed and is described in Section 2 below. The methodology is generalizable to the extent that it can be applied at various Army command levels (e.g., battalion, brigade, division, corps, and theater army) with only minor redefinition of the parameters of the methodology.

The subtasks performed are identified and discussed in the following subparagraphs.

1.5.1.1 Research Individual, Group, and Team Behaviors (Subtask 1.1)

The research of command group behaviors which was initiated during the first contract year was continued early in the second year. Particular attention was paid to individual and team behaviors associated with decision-making in general. This research broadened the information base available to the contract team and permitted the refinement of those behaviors applicable solely to military decision-making.

1.5.1.2 Define and Characterize Command Group
Effectiveness (Subtask 1.2)

It was necessary to define and characterize command group effectiveness in order to determine the contribution of non-procedural behaviors to that command group effectiveness. Command group effectiveness is manifested in planning, directing, and supervising combat operations; therefore, the definition and characterization of the elements of command group effectiveness have application to each of these command and control activities.

The initial examination of command group effectiveness indicated that such effectiveness may be measured both subjectively (qualitatively) and objectively (quantitatively). The characterization of command group effectiveness was extremely important to project performance, since such characterization dictated not only what data would be collected but how it would be collected. The instrumentation of CATTS, as well as the plans for observer participation in the project, was strongly dependent upon these effectiveness characterizations.

Combat effectiveness, as measured by battle outcome, is strongly dependent upon the relative combat power of opposing forces and upon the effective application of such combat power. Command group effectiveness is a major component of the application of combat power; therefore, project efforts related command group effectiveness to combat effectiveness and used the latter to

evaluate command group behavior.

1.5.1.3 Identify and Differentiate Command and Control
Behavior (Subtask 1.3)

The primary focus in the performance of Objective 1 was on non-procedural behaviors; therefore, it was necessary to identify command and control behaviors as either procedural or non-procedural for use in this project.

Procedural behaviors are simply those for which procedures for performance have been established or which are readily amenable to proceduralizing. Procedural behaviors are sequenced, and performance conforms to pre-established rules. In the military command and control environment, procedural behaviors normally include, but are not limited to, information input, recording, storage, retrieval, display, and output.

Correspondingly, non-procedural behaviors are those for which procedures for performance have not been established or which are not readily amenable to proceduralizing. Non-procedural behaviors are generally those involving mental processes of humans, in our case the members of the command group. These behaviors include, but are not limited to, assimilation of information, differentiation of information as to importance, integration of important information in order to perceive a situation, interpreting the information for impact on military

situations, and responding to situations with estimates, plans, and decisions.

The effective performance of both procedural and non-procedural behaviors contributes to command group effectiveness, and such behaviors are strongly interdependent. Much is known about procedural behaviors, and they may be subjectively analyzed and evaluated as to timeliness, accuracy, and completeness of performance. Conversely, little is known about the effect of non-procedural behaviors in command group effectiveness, and this fact was the underlying reason for the contracted effort of this project.

The approach to Objective 1 performance was to identify and describe the appropriate non-procedural behaviors. The set of non-procedural behaviors which were considered to exist and to have an impact on command group effectiveness then became important elements for quantification/qualification and analysis as to their individual and collective impact on the command group effectiveness. Many of the non-procedural behaviors applicable to this project were derived from the Army Training and Evaluation Programs (ARTEPs), Army field manuals, and the SAI model of command group behavior.

1.5.1.4 Classify and Characterize Non-Procedural Behaviors
(Subtask 1.4)

Non-procedural behaviors within a military command group may be exhibited either by individuals of the group or by the entire group (team) acting in concert. A major element in Objective 1 performance was to determine their respective contribution to command group effectiveness. The results of the first contract year indicated that it was necessary to refine the procedure for classifying non-procedural behaviors associated with the performance of a single function from those associated with the performance of a group of functions of which the single function is an element.

No distinction was made between the behavior of an individual performing a function and a group of individuals performing the same function: therefore, individual/multi-individual behavior was defined as behavior associated with the performance of a single function of a multi-function task by the element(s) of the single function group. Correspondingly, team behavior was defined as behavior associated with the performance of one or more functions of a multi-function task by two or more elements of the multi-function group. Team behavior is synergistic in nature.

Application of the definitions to Objective 1 performance is reflected in Figure 1-2 where the behaviors under consideration are the previously identified non-procedural behaviors. As an example, the non-procedural behaviors exhibited in performance of the staff intelligence function of the battalion command group are classified as individual/multi-individual behaviors in keeping with the definition. On the other hand, when the staff intelligence officer (S2) and the staff operations officer (S3) share the intelligence and relate it to operations matters, the behavior exhibited is team behavior. Both individual/multi-individual behavior and team behavior contribute to command group effectiveness, and it continues to be the objective of this project to develop a methodology for determining the respective contribution to each classification of behaviors to command group effectiveness.

The attention of the current contract effort was focused on the battalion command group; however, the definitions contained herein, as well as the methodology developed in keeping with these definitions, have equal application to command groups at brigade, division, corps, and theater army level. In fact, a general staff section at higher headquarters may itself be considered a team, and the branches of that section may exhibit individual/multi-individual and team behaviors contributing to the overall performance of the general staff section. The analysis of the hierarchy of behavior of a large staff section or of an even larger command group becomes

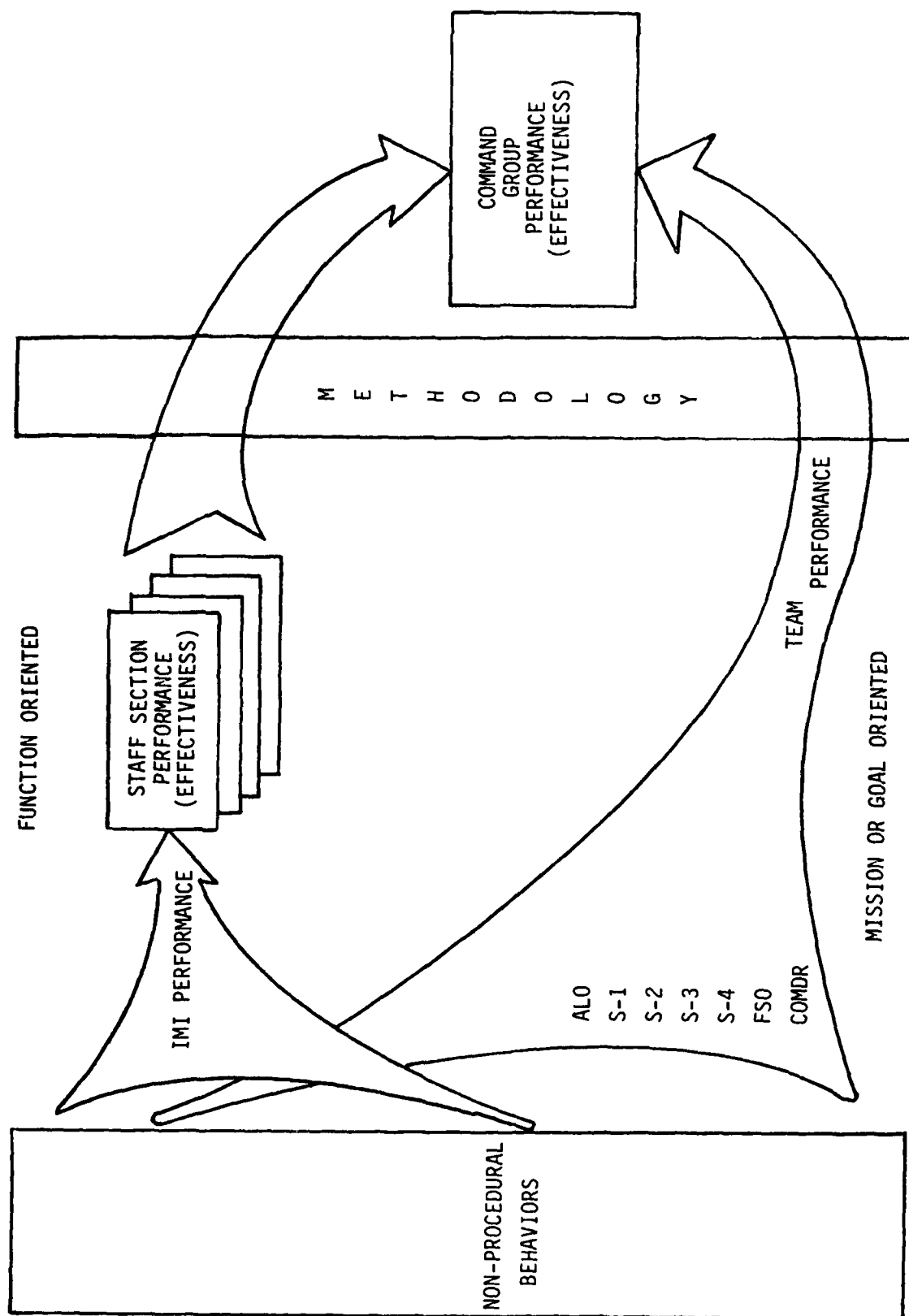


Figure 1-2. NON-PROCEDURAL BEHAVIOR VS. COMMAND GROUP EFFECTIVENESS

significantly complex and time consuming; nevertheless, the definitions still hold.

1.5.1.5 Develop Methodologies for Relating Non-Procedural
 Behaviors to Command Group Effectiveness
 (Subtask 1.5)

Having hypothesized the effect (command group effectiveness) and the cause (non-procedural behavior), SAI then developed an initial methodology for relating the cause to the effect. The methodology discriminates between the contribution of individual/multi-individual behavior and team behavior to command group effectiveness.

The initial step in methodology development was to establish critical hypotheses for relating behavior to effectiveness, and these hypotheses were tested as the methodology development proceeded.

The next step in formulating the required methodology was to differentiate the performance of individual/multi-individual behavior from team behavior in order that the contribution of each to command group effectiveness could be observed, measured, and analyzed.

The methodology which appeared to offer the greatest opportunity for success at this time involved the careful melding and analysis of several time stream comparisons. Three such time stream comparisons involve (1)

the transfer over time of information among nodes and staff sections of the command group (data transfer); (2) performance of non-procedural staff and command processes over time; and (3) the independent and the sequenced decisions made by the staffs and by the commander over time. Measures of effectiveness (MOE) of command group performance were carefully established for each element of the methodology.

An initial methodology for relating measures of effectiveness of command group performance to the various non-procedural behaviors was established such that each set of behaviors (individual/multi-individual and team) could be quantified and/or qualified utilizing the MOEs.

Finally, utilizing analytical techniques inherent to the initial methodology, an assessment was made of relative contribution of individual/multi-individual and team behaviors to command group effectiveness. Using selected data derived from actual observations and from audio and video tapes of CATTS exercise performance, the initial methodology was tested and refined.

1.5.2 Apply Analytical Methodologies (Task 2)

Upon completion of its design and development, the initial methodology was applied to data derived from the participation of a number of battalion command groups in CATTS exercises. Application of the methodology (a)

produced an evaluation of the contribution of non-procedural individual/multi-individual behaviors and the team behaviors to command group effectiveness, and (b) permitted the comparison of command group effectiveness among the battalion command groups for which exercise results were analyzed.

1.5.2.1 Review and Evaluate CATTS Environment, Procedures, and Documentation (Subtask 2.1)

A reasonably detailed knowledge of CATTS simulation, the manner in which the CATTS exercises are conducted and controlled, the identification of key player personnel by position, the instrumentation of the simulation for efficient game play as well as for behavior analysis, and the results of game play which are available for analysis were vital to Objective 1 performance.

For ready reference during task performance, the CATTS physical laboratory, the system instrumentation, and the organization and procedures for exercise play were reviewed and documented (Appendix C). Such information was essential to the observation and analyses of command group behavior and effectiveness.

1.5.2.2 Develop CATTS Analysis Plan Based on Initial
Methodology (Subtask 2.2)

Based upon the initial methodology for Objective 1, an analysis plan was developed to apply the methodology and to schedule and provide for the collection and analysis of behavior data. The analysis plan was not formalized; however, each of the following plan elements was developed and implemented during the second contract year.

- o Analytic procedures and techniques to be applied to CATTS exercise results were specified and analytical hypotheses were postulated for testing.
- o Performance and behavior measurement procedures were specified to include observation work sheets; desired detail, accuracy, and coding of the data observed; and entry of data into an automated data base.
- o Video and audio tapes of selected CATTS exercises were generated to support observation and analysis. Tapes from separate locations within the exercise environment were time-coded to permit their integration and analysis. Tapes recorded in the first year of Objective 1 activities were of insufficient quality to support analysis and application of the methodology;

therefore, tapes generated after the instrumentation system enhancement were selected for analysis.

- o Probe systems and associated scenarios were designed and developed to extract highly controlled behavior data from CATTS exercise play and to permit detailed analysis of command group behavior. The probe systems were utilized in only limited fashion during the second year.
- o An effective three-man observer team of senior military consultants was recruited and trained to review and interpret the video and audio tapes. Members of the team individually and independently extracted from the tapes the data for analysis and additionally provided expert judgments of performance of command group members based upon CATTS exercise play.

1.5.2.3 Collect Behavior Data (Subtask 2.3)

CATTS standard situation play data were collected, reduced where necessary, and later displayed for analysis. Audio data were collected by the taping of radio and telephone communications performed during exercise play.

Audio data were also taped using area microphones distributed in critical activity areas of the tactical operations center (TOC), the forward TOC (jump TOC), and the battalion trains headquarters. Audio/video data of the TOC, jump TOC, and battalion trains activities were also collected for behavior analysis using video cassette recorders. Audio and video data were time-coded for ease in synchronization and correlation. All recorded data were archived in a laboratory data recording system for ready identification and analysis by trained observers/consultants and by senior operations analysts.

1.5.2.4 Analyze Behavior Data (Subtask 2.4)

Analysis of non-procedural behavior data was driven by the initial methodology designed and developed for differentiating the non-procedural individual and multi-individual behaviors from the team behaviors and for determining their respective contribution to command group effectiveness.

From standard situational play data derived from the CATTS exercises, SAI prepared statistical and non-statistical analyses, tested and validated the hypotheses originally postulated, and prepared formal analysis reports for the exercises.

Battalion-level command groups participating in CATTs exercises could possibly be drawn from several sources; namely, Regular Army units; US Army Reserve and Army National Guard units; or from ad hoc organizations which participate to achieve some special objective. Intuitively, one might expect Regular Army command groups to exhibit behaviors and to perform more effectively in the exercise than would Reserve Component command groups. Correspondingly, the selection of uniquely qualified ad hoc command groups might optimize command group behavior and effectiveness. SAI was prepared to analyze behavior and effectiveness of command groups by source to determine if any significant differences exist; however, the very limited participation by Reserve Component and ad hoc battalion command groups did not support such analyses.

1.5.2.5 Validate Methodology (Subtask 2.5)

A comprehensive review of the initial methodology was conducted to validate the capability of the methodology to produce acceptable and useful results in the context of the tasking. This review produced positive answers to, at least, the following questions:

- o Were the parameters of the methodology quantifiable or qualifiable as used?
- o Were the mathematical and statistical techniques acceptable?
- o Considering the vehicle (simulation)

used, were the results realistic and logical?

- o Were the results consistent throughout all applications?

1.5.2.6 Document Methodology Application Results (Subtask 2.6)

The results of the application of the initial methodology during Objective 1, together with all supporting data, are formally documented and included in Section 3 of this annual technical report.

1.5.3 Enhance the Instrumentation System (Task 2.3)

Short term system improvements to instrumentation of CATTS exercise play were made during the first contract year to enhance the capability to extract useful information for behavior analysis and evaluation. During the second year, longer term and more expansive instrumentation improvements were made to permit collection as well as complete and thorough analysis of data. In performing this task, SAI

- o Researched instrumentation state-of-the art.
- o Prepared and maintained an instrumentation enhancement plan, which was

delivered to the COTR on August 31, 1982.

- o Coordinated with CATRADA/CATTS for the acceptance and scheduling of instrumentation enhancements.
- o Acquired (within available contract resources), configured, and tested the enhanced system (Appendix D).
- o Performed maintenance of instrumentation equipment for which ARI/SAI have maintenance responsibility.

1.5.4 Develop Performance Feedback System (Task 4)

A useful byproduct of Objective 1 performance during the second contract year was the identification and quantification of command group behavior so as to provide near real time feedback to CATTS player groups. To develop a system to provide this feedback package, the following subtasks were identified:

- o Define the general requirements for the feedback package
- o Structure the feedback package to include take-home components
- o Develop techniques for producing each package component and for integrating the components into a viable feedback package

- o Collect data necessary to produce a prototype feedback package
- o Produce and demonstrate the prototype feedback package and the system which produced it.

The performance of this task was only partially completed during the second contract year due to its dependence upon the enhancement of the CATTS instrumentation system. Additionally, Army resources necessary to operate a video editor system were not available, which limited feedback package development alternatives. Finally, it was determined that the use of CATTS as a training simulator would cease as of March 31, 1983, which caused reconsideration of the simulation exercise for which the feedback package would be developed. In view of these factors, SAI was granted permission to defer development of the feedback package until the third contract year. No further report of the performance of this task will be made in this document.

SECTION 2

METHODOLOGY

The principal task of Objective 1 is to develop and apply a methodology for differentiating the non-procedural individual and multi-individual behaviors from the team behaviors in battalion command groups and for determining their respective contribution to command group effectiveness. The development of the initial methodology is presented and discussed in this section, whereas the results achieved by the application of the methodology are presented in Section 3.

2.1 DEFINITIONS

An examination of contract tasking for Objective 1 invited definitions of terms appearing in the Statement of Work if development of the initial methodology for analyzing command group behavior was to proceed in a disciplined fashion. The specific terms of interest were "non-procedural behaviors" (and implicitly "procedural

behaviors") as well as "individual, multi-individual, and team behaviors". A literature search provided valuable insights into these definitions.

Adapting an accepted definition of behavior (Webster 1981) to the research activity at hand, a behavior is an act, function, or reaction which is relevant to command group performance and which can be observed in the CATTS laboratory.

The definitions of procedural and non-procedural behaviors were addressed first in order to properly focus project attention on the non-procedural behaviors. The first step in defining the terms was to examine Army doctrinal literature which addressed staff organizations and functions at multiple levels of command. The literature search included principally Department of the Army field manuals (FMs 71-2, 71-100, 100-5, 100-10, 100-15, and 101-5) and Army Training and Evaluation Programs (ARTEPs 71-2, 100-1, and 100-2). While the literature identified and described command and staff functions and procedures, the definitions of procedural and non-procedural behaviors were not obvious. The next step was to seek counsel from military analysts, including active duty and retired Army officers and Civil Service employees of the Army who were familiar with military command and control activities. Consultants within, or available to, SAI were also exploited for inputs to these definitions. The discussions with all knowledgeable personnel led to a general recognition that

definitions of these behaviors depended upon the ability to identify and describe the procedures for the performance of staff functions. From descriptions of a variety of staff activities, it appeared that if the replication of staff behavior in accordance with established procedures would produce substantially identical results, the behaviors should be classified as procedural. On the other hand, if the procedures could not be acceptably identified and described, or if replication of staff behavior in accordance with established procedures would not produce acceptably uniform results, the behaviors should be classified as non-procedural. In keeping with this rationale, then, SAI defined procedural and non-procedural behaviors as follows:

- o Procedural behaviors are those for which procedures for performance have been established or which are readily amenable to proceduralizing. Procedural behaviors are sequenced, and performance is largely mechanical and conforms to pre-established rules. In the military command and control environment, procedural behaviors normally include, but are not limited to, information input, recording, storage, retrieval, display, and output.
- o Non-procedural behaviors are those for which procedures for performance have not been established or which are not

readily amenable to proceduralizing. Non-procedural behaviors are generally those involving mental processes of humans, in our case the members of the command group. These behaviors include, but are not limited to, assimilation of information, classification of information as to importance, integration of important information in order to perceive a situation, interpretation of the information for impact on military situations, and responsiveness to situations with estimates, plans, and decisions.

The effective performance of both procedural and non-procedural behaviors contributes to command group effectiveness, and such behaviors are strongly interdependent. Much is known about procedural behaviors, and they may be objectively analyzed and evaluated as to timeliness, accuracy, and completeness of performance. Conversely, little is known about the effect of non-procedural behaviors in command group effectiveness, and this fact is one of the underlying reasons for the contracted effort of this project. Non-procedural behaviors considered in the SAI-developed methodology are exhibited in the performance of ten staff processes as discussed in paragraph 2.5 below.

Having defined procedural and non-procedural behaviors for application to contract performance, definitions of individual, multi-individual, and team behaviors were next addressed. Particular attention in defining these terms was paid to the ARI tasking documents and to experience gained during first year contract performance.

For the purpose of current contract performance, SAI subscribes to the belief that the identification, codification, and quantification of non-procedural multi-individual behavior can be viewed as synonymous with corresponding activities relating to non-procedural individual behaviors; i.e., that multi-individual behavior consists of nothing more than behavior of two or more individuals who are associated in a functional (group) context, who may or may not be a member of a team, and whose behavior is clearly dependent upon individual skills, experience, behavior, and products. Individual/multi-individual behavior is function-oriented and differs substantially from team behavior. In keeping with this rationale and for the purpose of developing the initial analytical methodology, SAI defines individual/multi-individual (IMI) behavior as behavior associated with the performance of a single function of a multi-function task by the element(s) of the single function group. As an example, the intra-section behaviors exhibited by one or more members of the battalion S2 section in the performance of the staff intelligence function are

classified as individual/multi-individual behaviors.

Team behavior, on the other hand, consists of behavior of two or more individuals or staff elements which are performing different functions which must be integrated to accomplish a mission and which rely upon the coordinated participation of each element for successful mission accomplishment. As contrasted with organizational and functional attributes of individuals or groups of individuals, a team has a relatively rigid structure, organization, communication pattern, and mission; and the activities of each element are presented in recognized doctrine and procedures. SAI then defines team behavior as inter-staff section behavior associated with the performance of one or more functional elements (staff sections) of a multi-function group (battalion command group). Extending the example of individual/multi-individual behavior cited above, if the staff intelligence officer (S2) and the staff operations officer (S3) share information of the enemy (intelligence) and relate it to friendly operations matters, the behavior exhibited is team behavior.

The relationship between individual/multi-individual and team performance behavior is presented graphically in Figure 2-1. In the figure, individual behavior of a single function is indicated by (A). Multi-individual behavior of a single function is indicated by (B) and may include intra-functional coordination; however, it does not include inter-

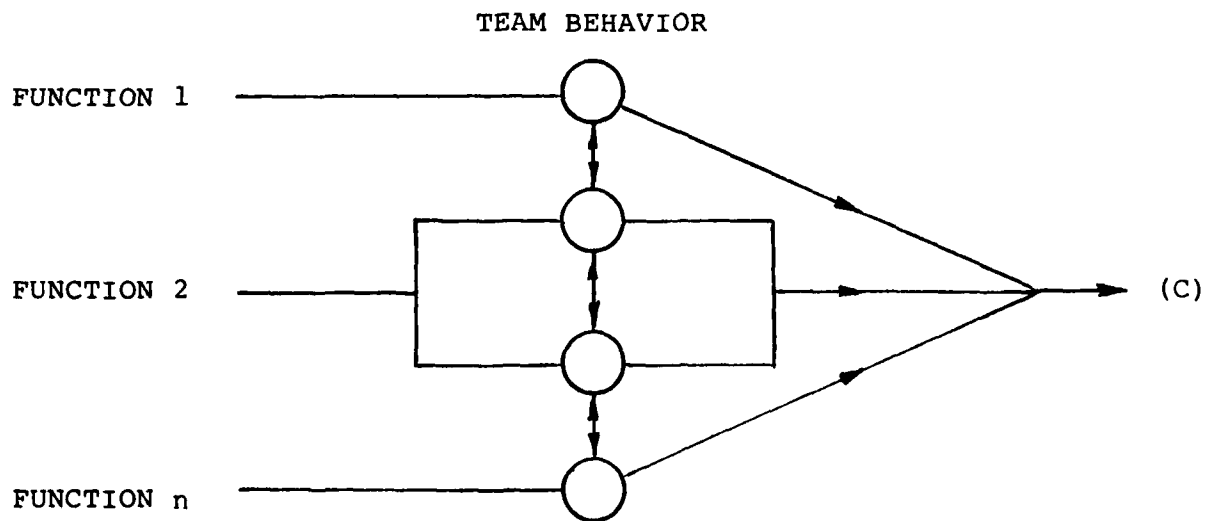
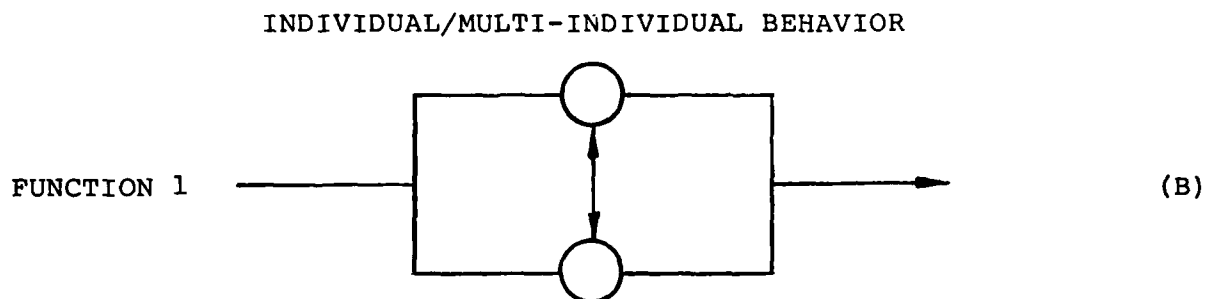
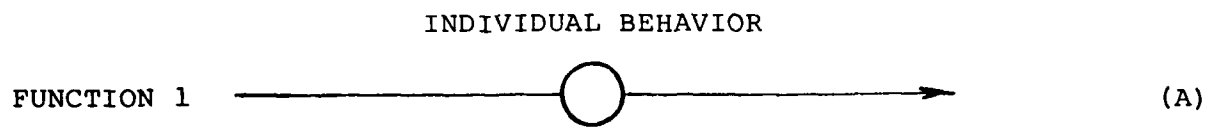


Figure 2-1. COMMAND GROUP BEHAVIOR

functional coordination. Team behavior is indicated in (C), includes inter- functional coordination, and results in functional integration for mission performance. The initial methodology which has been developed seeks to differentiate and evaluate the contributions of IMI and team performance to overall command group performance as well as to relate the overall command group performance of units participating in CATTS exercises. Command group performance is measured by the methodology as a function of organizational performance (battle outcome).

Application of the defined terms to various Army organizational levels was next explored primarily to ensure that any methodology developed could be generalized to a command group of any Army field organizational level. In the case of procedural versus non-procedural behaviors, it was determined that the definitions had universal application regardless of the field organizational level; however, it was observed that some purely non-procedural behaviors at battalion level tended to become, to some degree, procedural behaviors at corps and theater army level, principally due to the breadth and depth of the staff functions. A good example of this latter observation is the preparation of the staff estimate. Despite this tendency, the definitions remain valid.

The definitions of individual/multi-individual and team behaviors and their application at various Army organizational levels were next examined. At battalion

level, the command group (Figure 2-2) is organized functionally (personnel, intelligence, operations, and logistics) into coordinating staff sections, each with specific staff responsibilities. By organization the battalion command group is a team and exhibits team behavior in the performance of its multi-function, mission-oriented tasks. Each staff section at battalion level, however, performs its primary function as a group depending on the skills, experience, and availability of its constituents. Each battalion staff section, therefore, exhibits individual/multi-individual behaviors when performing its primary function.

A corps command group, at the other organizational extreme, is a highly structured organization (Figure 2-3). Its very organization brands the group as a team. Correspondingly, each coordinating staff section of the corps command group is highly structured, and itself could be considered as a team. Furthermore, each division, section, and branch of the corps coordinating staff may be considered as a team and may exhibit team behaviors in the performance of its assigned functions. Regardless of the highly structured nature of the corps command group, the definitions of individual/multi-individual and team behaviors still apply.

(Note: SAI is aware that some staff functions attributed to the corps ACoS G4 in Figure 2-3 may be performed by the corps support command staff; nonetheless,

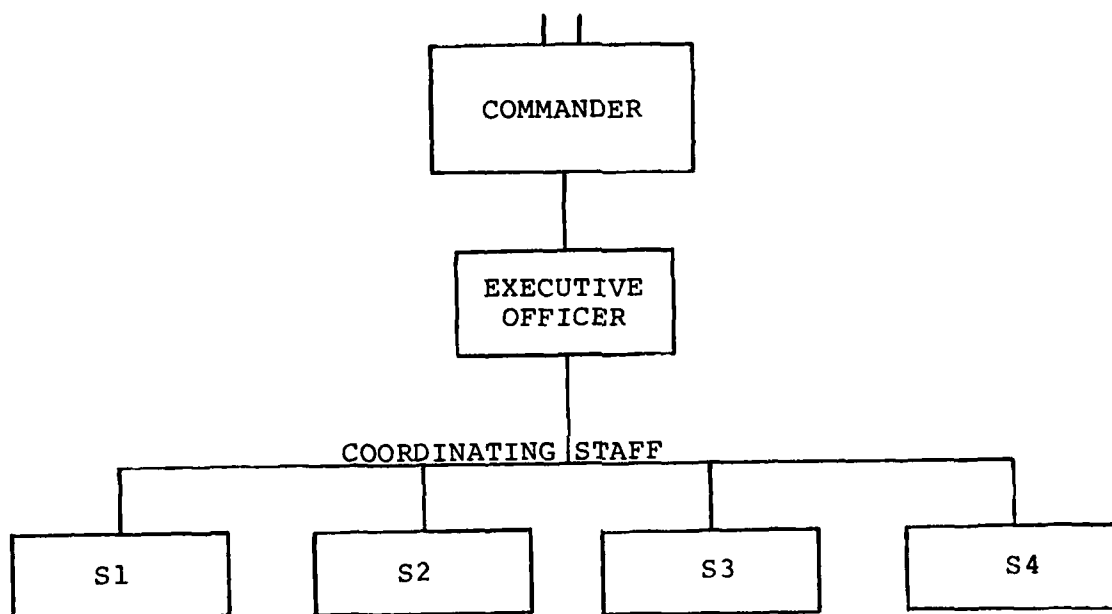


Figure 2-2. BATTALION COMMAND GROUP

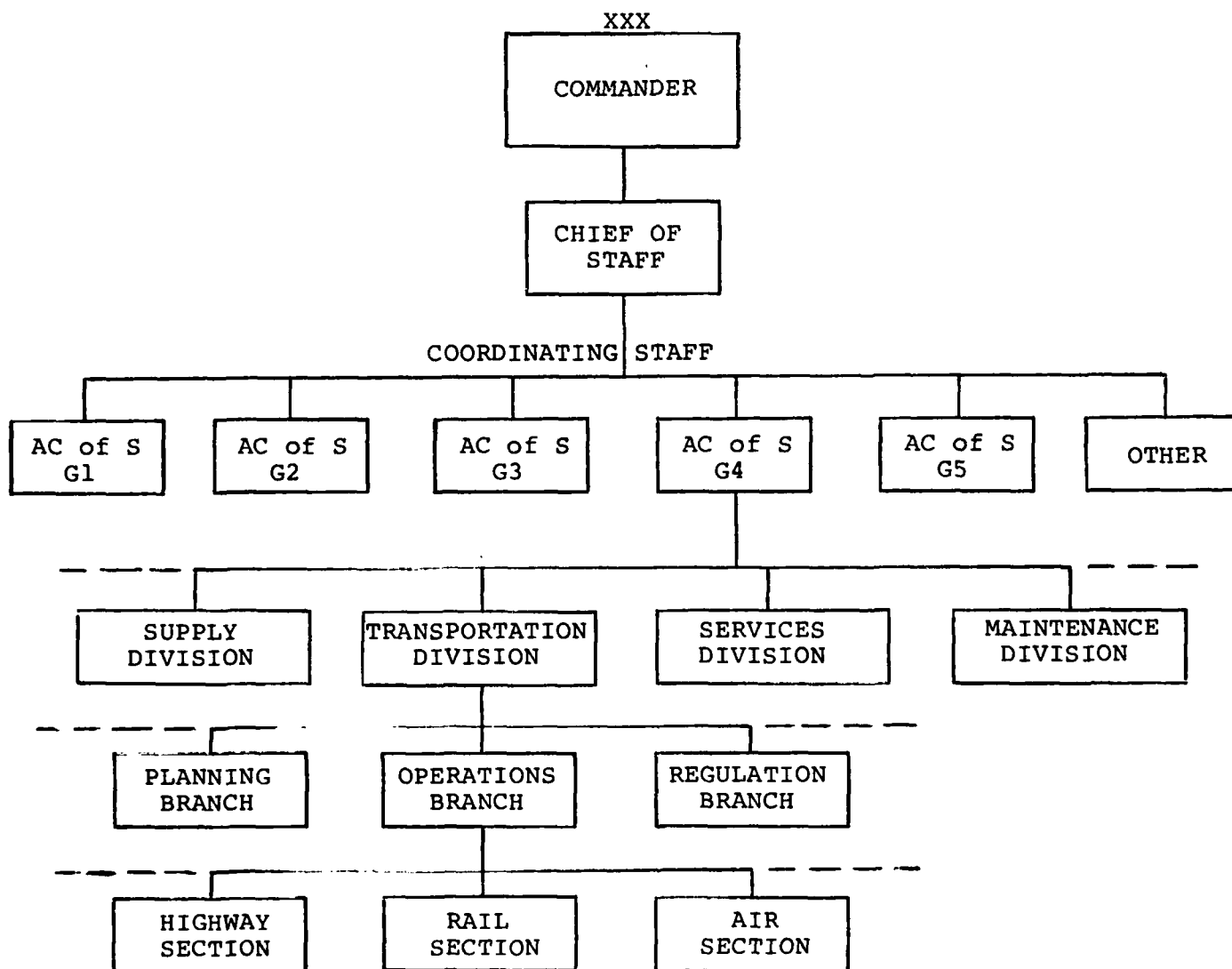


Figure 2-3. CORPS COMMAND GROUP (Notional)

the notional example of a corps command group is valid for application of staff behavior definitions.)

2.2 GENERAL APPROACH

In conceptualizing a methodology for evaluating command group behavior, it was necessary to identify means and measures for evaluating command group effectiveness, and this requirement generated a major challenge. A literature search did not reveal any acceptable methodology which could be used for such an evaluation. Limited techniques appeared to have been applied to portions of the evaluation requirement; however, none was sufficiently comprehensive to address the total requirement at hand.

A review of the conduct of simulation exercises using CATTS revealed that battle outcome information is recorded and retained on computer tape such that some measure of combat effectiveness is available. The information recorded is casualty information relating to both personnel and equipment. SAI then examined the possibility of relating command group behavior (performance) directly to combat effectiveness and deduced that such a relationship had merit. The relationship between command group effectiveness and combat effectiveness (battle outcome) as evidenced in CATTS exercises is reflected in Figure 2-4. Additional factors which may impact combat effectiveness are shown in the figure.

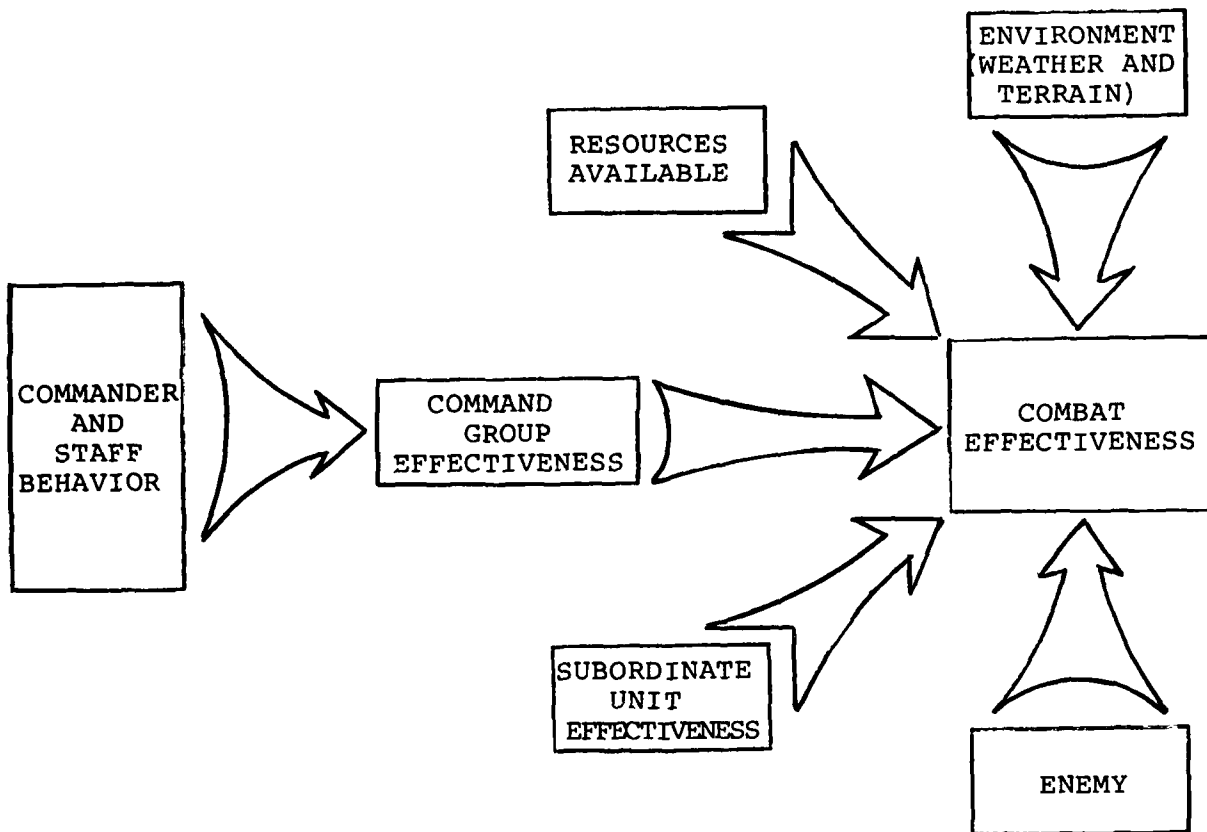


Figure 2-4. COMMAND GROUP EFFECTIVENESS VS. COMBAT EFFECTIVENESS

Considering the impact of the factors other than command group effectiveness shown in Figure 2-4, it was observed that the factors were either constant or were similarly applied by CATTS controller personnel such that they might be considered as basically constant. Using this rationale, it was assumed for application to CATTS exercise evaluations that the most significant independent variable influencing battle outcome was command group effectiveness. That being the case, behaviors of the command group could be examined and measured in terms of battle outcome of the simulated maneuver battalion operations. It was recognized that this measurement of command group effectiveness is soft and that an accepted challenge to this assumption could possibly alter the finding and conclusions of the project. It is further recognized that other measures of command group effectiveness, independent of battle outcome, are necessary of investigation; however, investigation of these other measures and their convergence with the initial methodology will be reserved for contract activities during the third contract year.

The next step in the general approach to developing the methodology was to identify measures which could be used to evaluate command group behavior and which had the potential of influencing battle outcome. The project team recognized that the methodology developed must be capable of utilizing data which could be captured from the available laboratory, the CATTS exercises. The team considered and rejected from consideration at this time, an

evaluation of the performance of staff functions (personnel, intelligence, operations, and logistics); instead, the team concentrated on the generalized behaviors of staff members, both individually and collectively. An examination of activities and functions of battalion command groups participating in CATTS exercises led to the identification of three major behavior types which were readily observable and interpretable and which would lend themselves to an evaluation of command group performance. Furthermore, information regarding each of these non-procedural behaviors could be collected using instrumentation available for CATTS. The three behaviors are:

- o Data transfer - the extent to which the battalion command group communicates internally as well as with higher, lower, adjacent, and supporting organizations.
- o Staff process performance - the individual and collective behavior of the command group in the performance of generalized staff activities.
- o Decision-making - the frequency and composition of battalion command group decisions in the prosecution of the simulation.

The general approach, then, conforms essentially to the research plan which is presented in paragraph 1.5 of this report and which is presented schematically in Figure 1-2.

SAI's initial methodology for evaluating command group behavior is synthesized into the following sequential steps:

- o Understand thoroughly the battalion command group organization and functions (see paragraph 2.3 below).
- o Instrument the CATTS facility to permit recording of all command group behavior during exercise play (Appendix D).
- o Using the instrumentation in the CATTS facility, record on video and audio tape all activities of the battalion command group simulation exercise.
- o Extract from the tapes and record all data transfers (communications) among members of the battalion command group as well as between the command group and external sources (higher, adjacent, supporting, and subordinate organizations); codify the data transfers by type and subtype as well as by communication mode; relate the frequency and duration of data transfers and use of communication modes to combat

effectiveness (see paragraph 2.4 below).

- o Codify the data transfers into the non-procedural behaviors (processes) to which they are associated; classify the processes as to individual/multi-individual or team behavior; relate the frequency and duration of process performance to command group effectiveness (see paragraph 2.5 below).
- o Codify decision processes by decision components; relate frequency of use of decision components to combat effectiveness (see paragraph 2.6 below).
- o Deduce the overall impact of command and staff behavior upon command group performance and ultimately upon combat effectiveness (battle outcome).

2.3 BATTALION COMMAND GROUP ORGANIZATION AND FUNCTIONS

Armored, mechanized, and infantry divisions are organized as shown in Figure 2-5. Airborne and air assault divisions have similar organizations but are more especially tailored to their missions and operational capabilities. Maneuver battalions are the basic fighting elements of these divisions and are the primary focus of our attention in methodology development.



Organizational and doctrinally, a maneuver battalion is a battle element of a brigade or specially organized task force; correspondingly, significant communications and coordination are transacted between the battalion and its control headquarters. Maneuver battalions are not administratively nor logistically self sufficient and must depend upon their parent division or other control headquarters for combat support and combat service support. Maneuver battalions have as constituents a number of companies which are the fighting elements of the battalion. A mechanized infantry battalion, for example, is organized as shown in Figure 2-6.

Maneuver battalions are frequently task organized into battalion task forces, wherein a combination of tank and mechanized infantry companies and other units are grouped under a tank or mechanized infantry battalion command group. A typical battalion command group is organized as shown in Figure 2-7.

Extensive communications and coordination incident to combat operations are carried out between the battalion commander and his staff; between the battalion command group and the battalion task force constituent elements, including those elements of the combat support company which may be operating under battalion control; and between the battalion command group and its control headquarters. Maneuver battalion command groups communicate frequently with their direct and general support field artillery, air

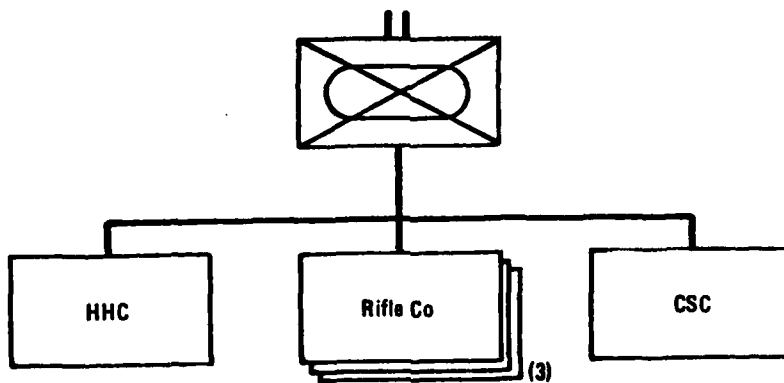
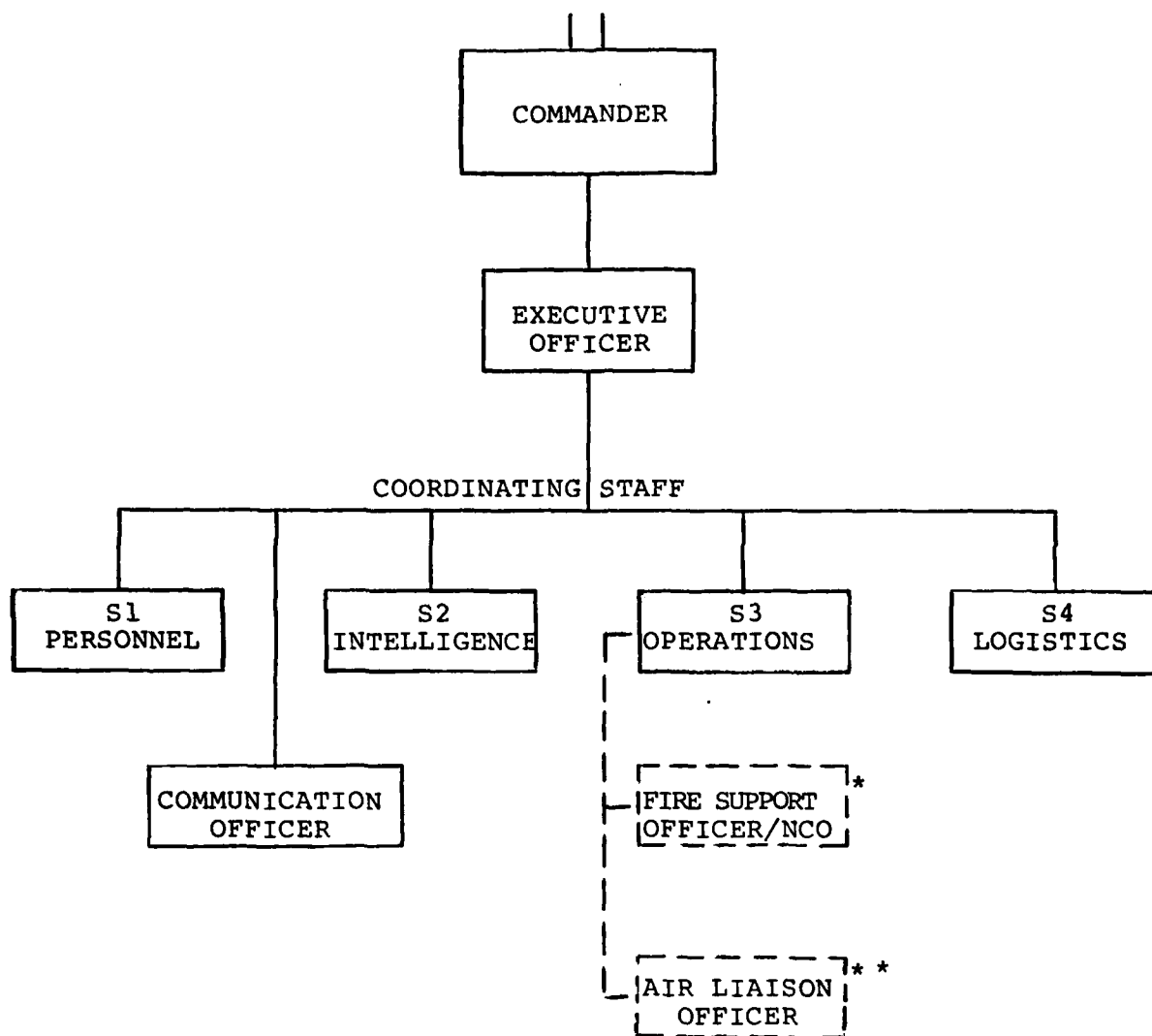


Figure 2-6. MECHANIZED INFANTRY BATTALION



*From direct support artillery battalion

**From supporting USAF organization

-- Functional association

Figure 2-7. TYPICAL BATTALION COMMAND GROUP

defense artillery, attack helicopters, and engineers as well as with tactical air support elements of the US Air Force. On rare occasions, communications with supporting elements may include naval gunfire support. Finally, to ensure proper coordination of combat operations, battalion command groups will coordinate frequently with right adjacent and left adjacent battalion level organizations.

In the command and control of combat operations, the primary efforts of the battalion staff are directed to assisting the battalion commander in making effective decisions and in supervising battlefield operations. In performing their individual and team functions, staff members coordinate and exchange information with each other as well as with higher, adjacent, supporting, and subordinate organizations. The typical battalion command group communications are shown in Figure 2-8. The battalion commander is the locus of all battalion command group activity; however, communications may be exchanged between any two elements depicted in the figure. To simplify the communications pattern in the figure, only the S3 Section communications are shown.

Within a staff section, communications among section personnel may be carried out freely as illustrated in Figure 2-9. In the figure, communications only between the S3 and each of the S3 Section members is shown; however, each section member is free to communicate with every other staff section member as well as with all staff

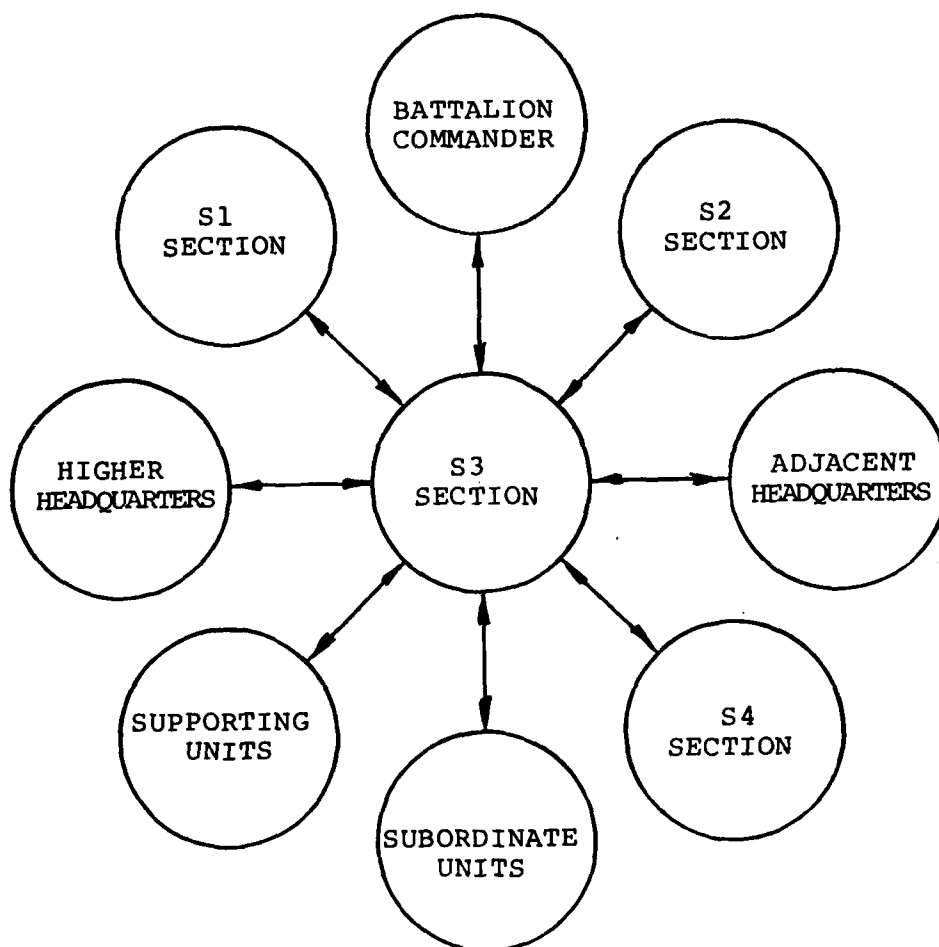


Figure 2-8. TYPICAL BATTALION COMMAND GROUP COMMUNICATIONS (S3 SECTION ONLY)

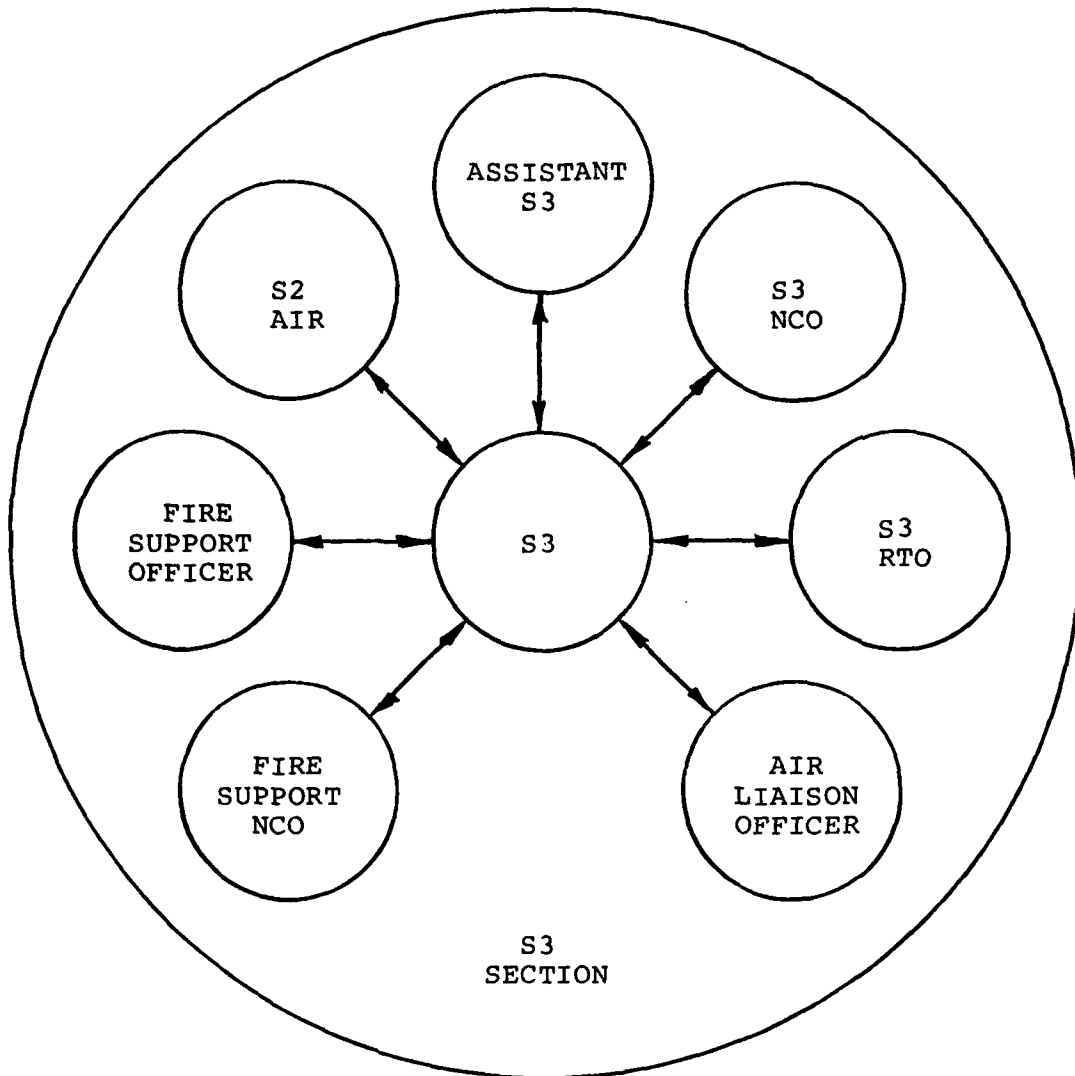


Figure 2-9. INTRA-STAFF SECTION COMMUNICATIONS (S-3 ONLY)

and command elements external to the S3 Section.

The overall command group activities are reflected in Figure 2-10, and it is within the context of these activities that the initial methodology was developed and applied.

2.4 DATA TRANSFER

An effective flow of data among battalion command group members, as well as between the command group and external sources (higher, lower, adjacent, and supporting organizations) is essential to the preparation of staff and commander estimates of the situation, to the making of optimum decisions, and to the supervision of the battle, all of which contribute to acceptable battle outcome. Without the sharing of information, few, if any, of the essential command and control processes could be performed. A principal thrust of SAI's effort in developing the initial methodology, therefore, was to consider and analyze the data transfer patterns of the battalion command group and, where possible, to relate these patterns to command group effectiveness.

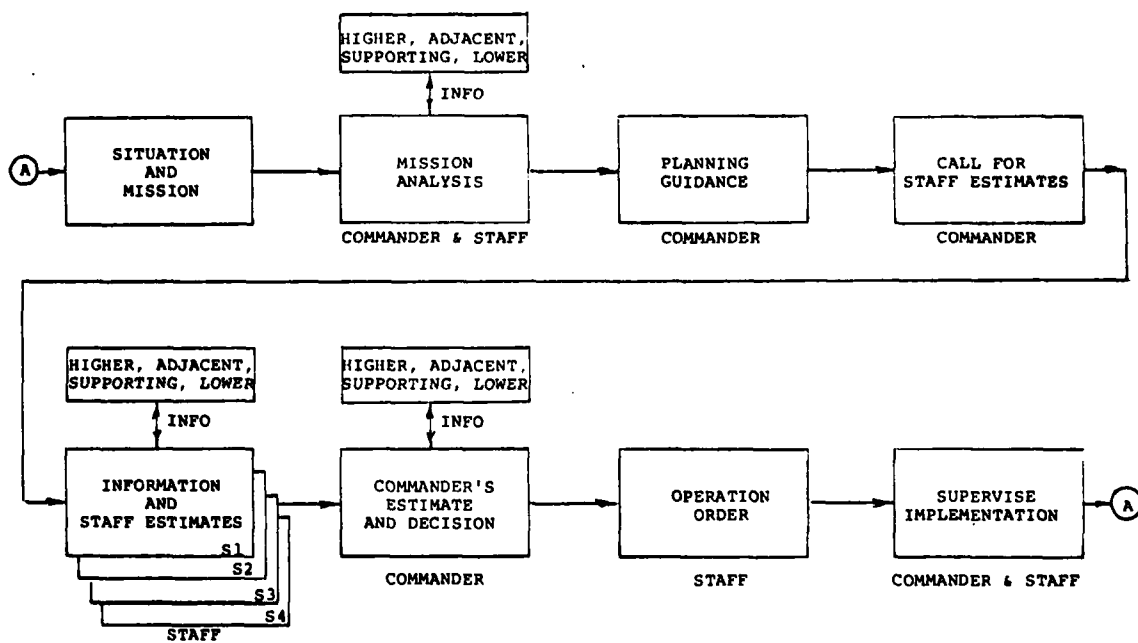


Figure 2-10. BATTALION COMMAND GROUP ACTIVITIES

2.4.1 Data Transfer Analysis

In analyzing data transfer patterns, two options for such analyses were considered; namely, to analyze data transfer quantity or data transfer quality. SAI opted to analyze the quantity, general content, and communication mode of the data transfers and to relate these factors to combat effectiveness. The decision was based upon the relative ease of acquiring data from the CATTS laboratory, the facility with which data could be classified for analysis, and the positive relationship of the data transfer quantity and content to staff process performance. To analyze the quality of data transfers appeared to dictate the development of a detailed information flow model and the establishment and application of complex guidelines for the uniform, judgmental evaluation of data quality. In the latter case, the data transfers would be evaluated for style, accuracy, relevance, completeness, and timeliness, and such an approach appeared to demand more time and other resources than were available at this stage of the exploration.

Since the first goal in the analysis of data transfer patterns was to establish a relationship between data transfer quantity and combat effectiveness and the length of the simulation exercises was variable, it was decided that measures of data transfer should be reduced to rates as well as to ratios of duration of transfers to overall battle duration. From a number of candidates, the

following measures were selected for investigation of data transfer quantity/combat effectiveness relationships:

Data transfer rate, individual/multi-individual

Data transfer rate, team

Data transfer rate, total

Data transfer duration ratio, IMI

Data transfer duration ratio, team

Data transfer duration ratio, total

Communication mode rate, radio

Communication mode rate, telephone

Communication mode rate, face-to-face

Communication mode duration ratio, radio

Communication mode duration ratio, telephone

Communication mode duration ratio, face-to-face

To investigate the specific relationships, hypotheses were stated to describe as logically as possible the probable relationships between data transfer measures and combat effectiveness. The hypotheses to be tested as part of the initial methodology are as follows:

Hypothesis DT1: Data transfer rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT2: Data transfer duration ratio is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT3: Telephone communication rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT4: Radio communication rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT5: Face-to-face communication rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT6: Telephone communication duration ratio is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT7: Radio communication duration ratio is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis DT8: Face-to-face communication duration ratio is curvilinearly (inverted U) related to combat effectiveness.

The curvilinearity (inverted U) hypothesized above is developed from the generalized model depicted in Figure 2-11. For low activity levels of the type being investigated, low effectiveness may be expected. As the

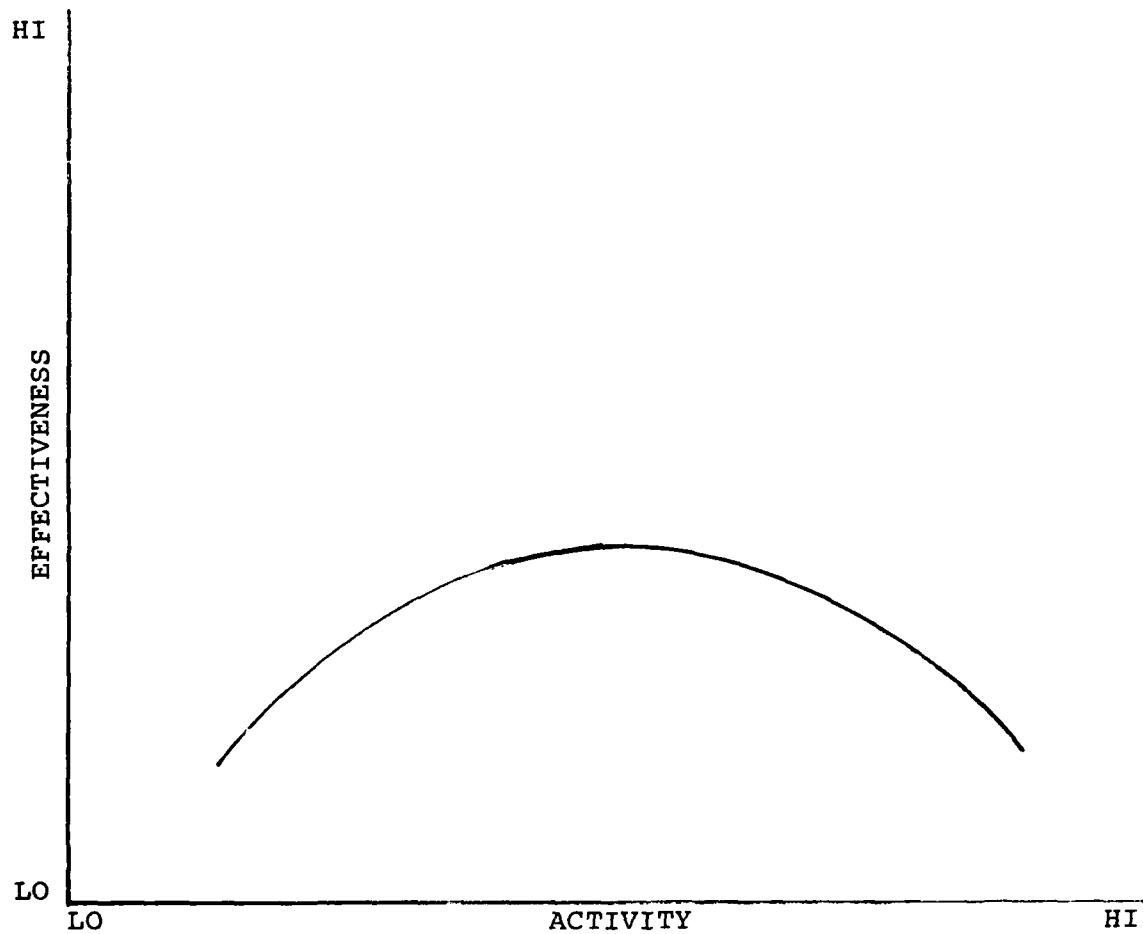


Figure 2-11. MODEL OF EFFECTIVENESS VS. ACTIVITY

activity level increases, a corresponding rise in effectiveness may be expected until a maximum of effectiveness is achieved. Activity levels beyond that which produced the maximum effectiveness may be expected to result in decreasing effectiveness.

There are obviously many more hypotheses which may be stated and tested, and the results of such testing may provide valuable insights into the relationship of data transfers to combat effectiveness. A number of these relationships are more appropriately addressed in the staff process hypothesis testing rather than in the data transfer testing; therefore, the number of data transfer hypotheses which were tested is useful but relatively limited.

Variable exercise durations, differences in task force organization, differences in tactical missions, and alternative geographical environments for exercise play impact upon data transfer quantity. Probably the most significant factor which would cause major perturbations in methodology results would be differences in tactical missions; therefore, analytical results should be interpreted in that light.

The results of the hypothesis testing for data transfer activities are presented in paragraph 3.3.

2.4.2 Collection of Data Transfer Information

The collection of data transfer information was facilitated by the extensive instrumentation of the CATTS facility, much of which was achieved by efforts under this contract. Video and audio recordings of all areas in which exercise play takes place (i.e., TOC, jump TOC, and battalion trains) provide a complete record of battalion command group activities as they can be seen and heard. Simultaneous time-coded recording of the command group activities permits the integration on a single time line of all such activities. This technique permits a direct comparison of command group activities and corresponding battle results over any selected time period. For application of the initial methodology, the time period chosen was the entire simulation; however, other periods of time may be selected for the examination and analysis of specific command group activities (see paragraph 2.9 below for a discussion of probes).

Data collected for each exercise are dictated by the length of the exercise, including the planning session, the exercise live play, and any post exercise critiques. For all activities associated with a single exercise day, a set of tapes would normally include:

- o Eight video cassettes recorded at slow speed (four for the TOC and two each for the jump TOC and the battalion trains area)

- o One 20-channel audio tape (partial)
- o One 9-track computer tape (partial)

The video and audio tapes must be interpreted by trained consultants in order to produce data for analysis. Data on the computer tape are accessed and manipulated to produce combat effectiveness scores (see paragraph 2.10 below), which are used in testing both data transfer and process hypotheses. The video and audio tapes are cataloged and archived in the SAI facility in Leavenworth, Kansas. The computer tapes are archived in the Data Processing Field Office (DPFO) at Fort Leavenworth, Kansas.

2.4.3 Interpretation of Data Transfer Information

The military nature of the activities performed by the battalion command groups, the environment in which the activities take place, the military communications and the communications electronics operating instructions (CEOI), the familiarity with military organizations and staffs, and the facility for identification of exercise players with staff activities dictated the selection of military experts for the interpretation of video and audio tapes. From among approximately 15 candidates for the military consultant positions, three were selected and consummated consulting agreements with SAI.

The team of three expert military consultants (a brigadier general, a colonel, and a lieutenant colonel, all retired) viewed separate taped exercises and, in keeping with rules of the methodology, classified manually the data needed for analysis. The classification of such data was tedious and time-consuming, but the technique chosen was the only alternative open for acquiring sufficient data for analysis. For each of his assigned simulation exercise, the military consultant viewed separately the staff behavior at each of three command locations (TOC, jump TOC, and battalion trains). Essentially, the activity of each staff member at each location was observed, classified, and recorded in order to evaluate the contribution of each to overall command group performance. In a relatively heavily populated location (e.g., TOC) it became necessary for the consultant to subdivide the activities by staff section (e.g., S2, S3) in order to record completely and to classify the data transfers. Once all of the data relating to a single simulation exercise were recorded and classified, the data were entered into an automated data base and were verified for accuracy and completeness. The data were then available for analysis by Objective 1 team members and by the Army Research Institute.

2.4.4 Interrater Reliability

In an attempt to establish observer reliability among the three military consultants as an aid in meaningful interpretation of data, each consultant was required to observe and classify data from a common segment of a single simulation exercise. The resulting three sets of behavior data were then subjected to analysis of variance techniques (Winer, 1971) to produce an interrater reliability score for the data transfer and process classifications discussed below. The threshold for accepting reliability was set at $R = 0.7$ with the knowledge that any score less than 0.7 accounts for less than 50 percent of shared observer variance. The results of the interrater reliability correlations are discussed further and reported in paragraph 3.2.

2.4.5 Data Transfer Classifications

Analysis of the communication of information between nodes of the battalion command group, as well as between members of the command group and force elements external to the command group, is a major element of SAI's initial methodology for evaluating command group behavior. To support these analyses, data transfer information of various classifications relevant to command group performance of Army doctrinal activities was recorded.

For the purpose of cataloging data transfers for subsequent use in behavior analysis, information recorded was identified with the battalion command group participating in the simulation exercise (coded for anonymity), the calendar date of the exercise, the exercise scenario day, and the simulated military operation being played. Additional information relating to probe use was recorded, if appropriate. For the format of these data, see the header information in the form displayed in Figure 2-12.

Data transfer classifications and their meaning are discussed below.

2.4.5.1 Start Time and End Time

The start and end times for each data transfer were recorded to the nearest second. This information was recorded for three main purposes; namely,

- o To signify that a data transfer took place.
- o To permit later calculation of frequency and duration of both data transfers and related staff processes.
- o To permit correlation of activities taking place concurrently in three simulated locations.

UNIT _____

DATE _____ EXERCISE DAY _____

SCENARIO FULDA _____ ATTACK _____ DELAY _____

 SINAI _____ DIVISION ATTACK _____ DELIBERATE DEFENSE _____

 IRWIN _____ COVERING FORCE _____ HASTY DEFENSE _____

 MOVEMENT TO CONTACT _____

PROBE NUMBER _____ PROBE DESCRIPTION _____

[illegible]

2-37

2.4.5.2 Communication Mode

The use of verbal and written communications is an integral component of the initial methodology for analyzing command group behavior; therefore, the communication mode for each data transfer was recorded as follows:

R - radio

T - telephone

F - face-to-face

N - note, message, or document

If a staff process took place and did not involve an observable data transfer (e.g., assessing the situation), no entry was made in the collection form under communication mode.

2.4.5.3 Sender and Receiver

Using the assigned alphanumeric character from the exercise communications- electronics operating instructions (CEOI), each sender and receiver was uniquely identified. The sender and receiver identification permitted the classification of behavior into individual/multi-individual and team categories for analysis.

The quality of the data transfer was graded only for excellent (+), acceptable (0), poor (-) performance. The majority (99%) of the transmissions were graded as acceptable; therefore, data transfer quality did not

contribute in a meaningful fashion to behavior analysis.

2.4.5.4 Data Transfer Type

The content of each data transfer was classified by type and subtype to support analysis in accordance with the initial methodology. Classifications were as follows:

- 1 Information
 - 1.1 Enemy
 - 1.2 Friendly
 - 1.3 Environment (weather and terrain)
- 2 Request
 - 2.1 Information
 - 2.2 Resources
 - 2.3 Authority
- 3 Coordination*
 - 3.1 Intra-command group
 - 3.2 Higher headquarters
 - 3.3 Supporting units
 - 3.4 Adjacent units
 - 3.5 Subordinate units
- 4 Orders/Directions/Instructions*
 - 4.1 From higher headquarters
 - 4.2 To subordinate units
 - 4.3 Intra-command command group

5 Null

5.1 No observable data transfer

* Subtypes do not necessarily classify content but are used to facilitate analysis.

2.4.5.5 Behavior Type

Command group behavior associated with the data transfer is classified as either individual/multi-individual (I) or team (T), in keeping with the definitions contained in paragraph 2.1.

2.4.5.6 Process Type

All data transfers recorded by the military consultant are integral to a staff process being performed by one or more elements of the battalion command group, and the associated staff process is classified and entered on the data collection form. Staff processes are classified and described in paragraph 2.5.1 below; however, the process coding is presented here for the association with the data collection activities. The processes are classified by the activity being performed by the battalion command group; for example, an external source may be transmitting information but the battalion command group is receiving information, and the process is classified as the latter.

<u>Process Type</u>	<u>Process Identification</u>
1	Seek information
2	Receive information
3	Consider alternatives and decide
4	Implement decision
5	Coordinate
6	Transmit information
7	Supervise the staff
8	Request resources/authority
9	Receive order, directives, in- structions
10	Assess situation

To provide guidance for the classification of data transfers and processes, a matrix of allowable relationships was developed and is presented in Table 2-1.

2.4.6 Simulation Exercise Data

From mid-December 1982 through March 1983, the three military consultants interpreted the video and audio tapes for the battalion command groups shown in Table 2-2. The exercises selected for interpretation were those which would provide input to the Training Development Study (TDS) being conducted concurrently by the Army Research Institute. Time and resources did not permit the interpretation of all CATTS exercises recorded during the second contract year; however, other recorded simulation exercises were used in

Table 2-1. ALLOWABLE DATA TRANSFER TYPE/PROCESS TYPE RELATIONSHIPS

	INFORMATION			REQUESTS			COORDINATION					ORDERS, DIRECTIVES, INSTRUCTIONS			
	1.1 ENEMY	1.2 FRIENDLY	1.3 ENVIRONMENT	2.1 INFORMATION	2.2 RESOURCES	2.3 AUTHORITY	3.1 INTRA-COMMAND GROUP	3.2 HIGHER HQ	3.3 SUPPORTING UNIT	3.4 ADJACENT UNIT	3.5 SUBORDINATE UNIT	4.1 FROM HIGHER HQ	4.2 TO SUBORDINATE OR SUPPORTING UNIT	4.3 INTRA-COMMAND GROUP	5.1 NO DATA TRANSFER OBSERVED
DATA TRANSFER TYPES															
PROCESS TYPES															
1. SEEK INFORMATION				X											
2. RECEIVE INFORMATION	X	X	X												
3. CONSIDER ALTERNATIVES AND DECIDE							X						X		
4. IMPLEMENT DECISION													X		
5. COORDINATE							X	X	X	X	X				
6. TRANSMIT INFORMATION	X	X	X												
7. SUPERVISE STAFF														X	
8. REQUEST RESOURCES/AUTHORITY					X	X									
9. RECEIVE ORDERS, DIRECTIVES, INSTRUCTIONS												X			
10. ASSESS SITUATION							X								X

Table 2-2. CATTS SIMULATION EXERCISES (TDS)

UNIT	DAY 2	DAY 3	DAY 4	DAY 5
BCG1	FULDA COVERING FORCE/ DELAY	SINAI COVERING FORCE	SINAI ATTACK	FULDA COVERING FORCE/ DELAY
BCG2	FULDA COVERING FORCE/ DELAY	IRWIN MOVEMENT TO CONTACT/ ATTACK	IRWIN DELAY	FULDA COVERING FORCE/ DELAY
BCG3	FULDA COVERING FORCE/ DELAY	IRWIN MOVEMENT TO CONTACT/ ATTACK	IRWIN DELAY	FULDA COVERING FORCE/ DELAY
BCG4	FULDA COVERING FORCE/ DELAY	IRWIN MOVEMENT TO CONTACT/ ATTACK	IRWIN DELAY	FULDA COVERING FORCE/ DELAY
BCG5	FULDA COVERING FORCE/ DELAY	IRWIN MOVEMENT TO CONTACT/ ATTACK	IRWIN DEFENSE	FULDA COVERING FORCE/ DELAY

BCG = Battalion Command Group

———— Exercise recorded, classified, and analyzed

----- Exercise recorded and classified but not analyzed

methodology development as well as for training of the military consultants.

2.5 PROCESS PERFORMANCE

The second major element in the development of the initial methodology was to analyze the manner and extent to which each staff node, each staff section, and the commander performed generalized staff processes. In identifying staff processes, special attention was devoted to behaviors which would be manifested by all staff members regardless of the staff section to which they were assigned. This approach is contrasted with an approach which would have analyzed and evaluated how well each staff section performed its assigned staff function (personnel, intelligence, operations, and logistics) and, correspondingly, how much the collective performance of all staff functions contributed to command group effectiveness. The latter approach would evaluate command group behavior but has the disadvantage of requiring a determination of the weighted contribution which each staff function makes to tactical decision-making.

2.5.1 Process Identification

A comprehensive review of Army field manuals (FMs 100-5, 100-10, 100-15, and 101-5) and ARTEPs (71-2, 100-1, and 100-2) was conducted to identify generalized staff

processes. Matrices such as the one displayed in Table 2-3 assisted in identifying and selecting for analysis the generalized staff processes. The processes selected for analysis and evaluation are identified and described in the subparagraphs which follow.

2.5.1.1 Seek Information

This process involves the overt act by a node of the battalion command group of requesting information (general or specific) relevant to staff activities or combat operations. Information may be sought within a staff section, between staff section, or between the nodes of the battalion command group and external sources (i.e., higher, adjacent, supporting, or subordinate units).

Once the request for information is initiated, the process includes the information returned, provided the communication (data transfer) is continuous. If a response is provided later by higher, adjacent, supporting, or subordinate units as a separate data transfer, the response is classified as receiving information.

Table 2-3. RELATIONSHIP OF ACTION VERBS TO METHODOLOGY PROCESSES

FM AND ARTEP ACTION VERBS	STAFF PROCESSES										
	SEEK INFORMATION	RECEIVE INFORMATION	DECIDE	IMPLEMENT DECISION	COORDINATE	TRANSMIT INFORMATION	SUPERVISE STAFF	REQUEST RESOURCES/AUTH	RECEIVE ORDERS/DIR	ASSESS SITUATION	
COLLECT	X										
UPDATE	X	X				X				X	
MAINTAIN	X	X			X	X					
COMPILE	X	X									
REQUEST	X							X			
RECEIVE		X			X				X		
MONITOR	X	X			X		X			X	
INTERPRET			X	X	X	X	X			X	
INTEGRATE			X	X	X		X			X	
EXAMINE			X		X					X	
ANALYZE			X		X					X	
ESTIMATE			X		X					X	
IDENTIFY			X		X					X	
EVALUATE			X		X		X			X	
PLAN			X		X		X			X	
RECOMMEND			X		X					X	
DEVELOP			X	X	X					X	
PREPARE (PLANS, ORDERS)			X	X	X	X	X			X	
ORGANIZE			X		X		X			X	
CORRELATE			X		X					X	
ALLOCATE			X	X	X	X				X	
ADVISE			X	X	X	X	X			X	
ESTABLISH			X	X	X					X	
INSTRUCT				X	X	X	X				
ISSUE				X	X	X					
DIRECT				X	X	X	X				
PROVIDE				X	X	X					
INFORM				X	X	X	X				
ASSIGN			X	X	X	X	X				
DESIGNATE			X	X	X	X	X				
IMPLEMENT				X	X	X	X				
ORDER				X	X	X	X				
DISSEMINATE				X	X	X					
COMMUNICATE		X		X	X	X	X				
TRANSMIT				X	X	X					
SUBMIT						X		X			
COORDINATE					X	X	X			X	
REPORT					X	X					
SUPERVISE				X	X		X				
TRAIN					X		X				
TRANSLATE			X	X	X	X					
FORMULATE			X		X					X	

2.5.1.2 Receive Information

This process involves the activity of receiving relevant information by a node of the battalion command group. Information may be received from higher, lower, adjacent, or supporting units but not from other nodes integral to the battalion command group. The exchange of information between nodes of the battalion command group is attributed to the sender, and the process is classified as transmitting information.

2.5.1.3 Consider Alternatives and Decide

This process is analogous to the staff and commander activities of preparing estimates of the situation. For the most part, the process is participated in by the commander and the principal staff officers. A staff officer "decides" when, as a result of his staff estimate, he selects his recommendations to the commander relating to his principal staff function.

2.5.1.4 Implement Decision

This process involves the translation of the decision into orders, directives, and/or instructions, as well as the distribution (by whatever means) and acknowledgment of the receipt of the orders. Implement the decision, as a staff process, may be attributed to any

command group node involved in the process. The process does not include or involve the execution of the decision by subordinate or supporting units.

2.5.1.5 Coordinate

The process of coordination is the integration of capabilities and/or activities so as to bring them into common action or condition and thus achieve unity of effort. The process is manifested by an overt act on the part of any command group node with any other node of the battalion command group as well as with higher, adjacent, supporting, or subordinate units. For analysis purposes, the process is attributed to the sender rather than the receiver.

2.5.1.6 Transmit Information

This process involves the transmission of relevant information between two nodes of the command group, or between a node of the command group and higher, lower, adjacent, or supporting units. Any node of the battalion command group may be involved in transmitting information.

2.5.1.7 Supervise the Staff

This process involves the action by a person in authority in instructing, directing, or ordering a subordinate member of the staff in the correct or more productive performance of a staff function or command group activity. It most frequently takes the form of diplomatic instruction in functional performance; however, it may take the form of a direct order. In occasional cases, the process may take the form of suggestions from an experienced subordinate to an inexperienced superior. The process may also take the form of overall orchestration of staff activities as might be conducted by a commander or chief of staff or as might be conducted by a principal staff officer for members of his particular staff section.

2.5.1.8 Request Resources/Authority

This process is an overt act by a node of the command group to seek/request resources or authority not currently authorized to the battalion. It will most frequently address requests for combat, combat support, or combat service support resources or for special authority not already granted to the battalion. If granting of the resources or authority is integral to the same data transfer requesting the resources or authority, the assignment of resources or authority is considered as part of this

process. On the other hand, if the assignment of the resources or authority is the subject of a later data transfer, the later process is classified as receiving orders, directives, or instructions.

2.5.1.9 Receive Orders, Directives, or Instructions

This process involves the receipt of orders, directives, and instructions from a headquarters authorized by organizational relationships or by special authority to issue such orders. For purposes of recording this process during CATTS exercises, the process is initiated by the parent brigade or task force. One node of the command group may not receive orders, directives, and instructions from another node of the command group, such a process being classified as supervising the staff.

2.5.1.10 Assess the Situation

This process essentially involves answering the question "what does this information mean in light of what I already know, or what I am doing?". The process of assessing the situation must be positively manifested through an act by a command group node who has been the recipient of information, orders, or coordination. The act of assessing the situation is a mental process which may or may not be articulated and which may or may not be manifested in any other way. The total activity of assessing the situation may not be observable from video and audio tapes; consequently, the total assessing-the-situation process will realistically be more than the sum of the observed processes. The process may be manifested by any node of the command group; however, the

most prolific manifestation can be expected from the commander and the principal staff officers.

2.5.2 Collection of Process Information

The collection of process information is accomplished by recording overt actions of a member of the battalion command group either in the form of a data transfer or in the form of an independent observable act on the part of a single member of the command group. Each data transfer which was recorded on the data collection form (Figure 2-12) was classified as to the staff process with which it was associated. Where processes not involving data transfers were observed, these observations were also recorded on the data collection form, and the processes were classified as to type. The process classifications, coupled with other information on the data collection form, permitted the determination of frequency and duration of performance of each process; the identification of participants in each process by node, dyad, and staff section; and the classification of behavior (individual/multi-individual versus team) exhibited in the performance of each process. Relationships among data transfers and staff processes are shown in Figure 2-13.

The availability of staff process classifications of the type collected permits aggregation of data to reveal such information as:

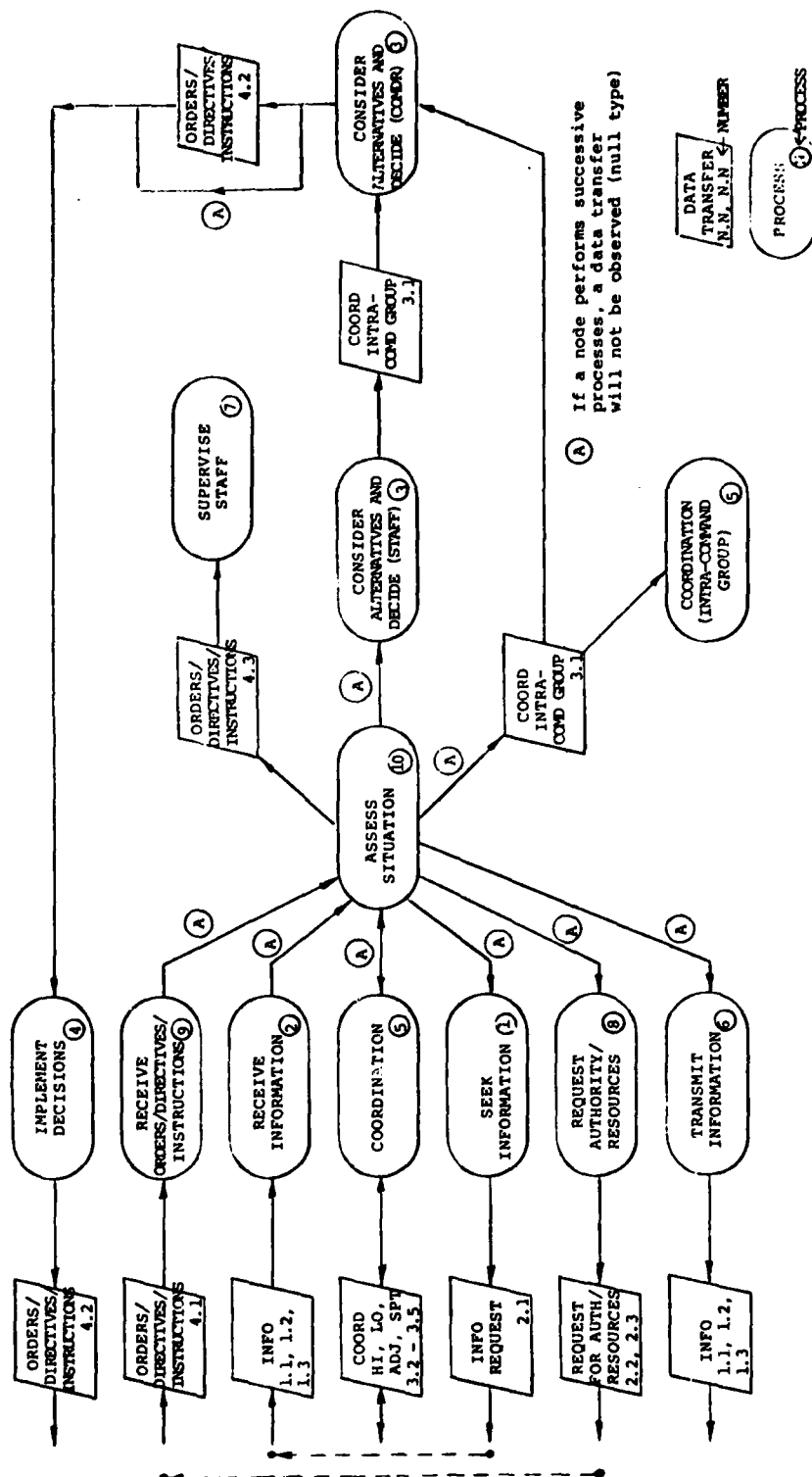


Figure 2-13. DATA TRANSFER VS. STAFF PROCESSES

- o Average nodal activity of each battalion command group for the simulation exercise in which it participates.
- o Duration of performance of each staff process as a function of total simulation exercise duration.
- o Patterns of process performance among staff sections and between the battalion command group and external sources.
- o Ratios of individual/multi-individual functional performance to team performance by the command group.
- o The ranking of processes by both duration and frequency of performance.

2.5.3 Process Methodology

The basic objective of the process methodology is to relate the various aspects of process performance to combat effectiveness (battle outcome). As with the data transfer methodology, variable length simulation exercises dictate that measures of process performance be reduced to rates and to process durations as functions of exercise duration. To investigate the specific relationships to be subjected to analysis, the hypotheses stated below were tested and the results analyzed.

Hypothesis P1: Process rate is curvilinearly (inverted U) related to combat

effectiveness.*

Hypothesis P2: Process duration ratio is curvilinearly (inverted U) related to combat effectiveness.*

Hypothesis P3: Individual/multi-individual behavior rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis P4: Individual/multi-individual behavior duration ratio is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis P5: Team behavior rate is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis P6: Team behavior duration ratio is curvilinearly (inverted U) related to combat effectiveness.

*Hypotheses P1 and P2 apply to each process as well as to total processes.

The rationale to support the curvilinearity of the relationships is presented in paragraph 2.4.1 above. It should also be noted that the maximum effectiveness for each rate and duration ratio should be expected to be different for each process or behavior. The results of hypothesis testing for process performance are presented in paragraph

3.3 below.

2.6 DECISION-MAKING

The third, and final, element of the initial methodology would be the examination and analysis of the actions of the battalion command group, principally the commander, in making decisions relating to exercise play and in supervising the implementation of the decisions. The commander is the beneficiary of aggregate command group behavior; therefore, the decisions he makes are a direct reflection of how well the balance of the command group performs their staff processes and functions. The decisions made and implemented would be expected to be directly reflected in combat effectiveness.

In developing this element of the methodology, the objective was to evaluate, over battle simulation duration, the frequency of decision-making and the composition of the decisions made. It was not the intent to document and evaluate the quality of each decision made by the commander. The frequency of the decisions made would, however, be a direct reflection of the quality of staff planning and of the command and control attributes of the staff and the commander. An analysis of the decision components was expected to reveal those most frequently and most effectively used to influence battle outcome.

Early in the time frame when recorded data were being interpreted, it became evident that the relatively short duration of each simulation exercise precluded the making of any significant decisions subsequent to the start of the exercise. The battalion commander, having made his decision and issued the necessary operation order for the exercise during the planning session, then became involved in orchestrating and supervising the execution of the order. While some directives and instructions were issued by the commander during exercise play, they were principally associated with the coordination of mission operations rather than the issuance of new orders. The paucity (or void) of decision-making activities severely inhibited the development of the third element of the methodology. While decision-making activities were not observable in this research effort, it is believed that such activities are highly relevant to battalion operations and should be the subject of future study. In the paragraphs which follow, the decision-making methodology is presented; however, the application of this element of the methodology did not occur during the second contract year.

2.6.1 Definitions

To provide a basis for common understanding of the decision-making methodology, definitions of the following two terms were necessary:

- o Decision - a conscious judgment on the

part of the command group, principally on the part of the commander, to pursue a particular course of action to achieve an assigned or assumed mission. The decision is manifested in the issuance of an operation order, complete or fragmentary, to subordinate and/or supporting organizations.

- o Decision component - a first order element of a decision which addresses a major capability to influence unit combat effectiveness (battle outcome). A decision may consist of one or more decision components (see paragraph 2.6.3 below).

2.6.2 Decision-Making Methodology

The methodology for the analysis of decision-making was developed principally to observe the behavior of the battalion commander in the performance of his decision-making activity. The methodology envisages that a commander will make an initial decision for accomplishment of his mission as the result of a planning activity by the battalion command group, and this decision will be distributed in the form of an operation order to those organizational elements which will execute the decision and perform the mission. With the initiation of

the mission, the commander would be continuously faced with the opportunity for successive decisions based upon information and staff advice and upon his perception of the progress of mission performance. The methodology addresses the behavior of the commander as he makes decisions to effectively pursue his mission objectives.

From time-coded process information pertaining to decisions exhibited during exercise play, an analysis can be performed which will relate the frequency with which decisions are made to combat effectiveness. An analysis of decision components in the same context will reveal the impact of the use (including frequency of use) of each decision component upon battle outcome. Future decision-making activity can, furthermore, be related directly to other contributory time-synchronous staff processes in order to:

- o Identify processes which contribute most directly and most frequently to decisions made.
- o Relate the timing of processes performed to the decisions made.
- o Relate the quantity and quality of process performance by type to the decisions made.

Although not addressed in second year efforts due to lack of data points, it is envisaged that decision components may be integrated over battle duration to reveal

the degree to which such integration influences combat effectiveness.

The basic objective of the decision-making methodology is to relate decision process performance to combat effectiveness. To investigate the relationships, the following hypotheses were postulated:

Hypothesis D1: The rate of decision-making is curvilinearly (inverted U) related to combat effectiveness.

Hypothesis D2: The ratio of decision components to decisions is negatively related to combat effectiveness.

Hypothesis D3: For selected decision components there is an optimal rate of use which produces the highest combat effectiveness.

The rationale for the hypotheses of curvilinearity is discussed in paragraph 2.4.1 above. Hypothesis testing for decision-making was not performed during the second year since the short duration of the exercises precluded any significant opportunities for decision-making during the exercises.

2.6.3 Identification of Decision Components

Each tactical decision made by a battalion commander includes components which, when executed by subordinate and supporting units, will influence the combat effectiveness of the battalion in the performance of its mission. One or more of these components will be included in each operation order issued by a commander. If all components are included, the result is a complete operation order; otherwise, the result is a fragmentary order.

In selecting decision components, the objective was to identify and include those which would have a significant impact upon battle outcome if included in the operation order. Additionally, each of the decision components should have approximately the same breadth and importance and thus could be treated as contributing approximately equally to battle outcome. The decision components chosen for analysis were:

- o Concept of operations
- o Mission, maneuver unit 1
- o Mission, maneuver unit 2
- o Mission, maneuver unit 3
- o Mission, maneuver unit 4 (if any)
- o Mission, maneuver unit 5 (if any)
- o Battalion organization for combat
- o Control and coordination measures
- o Indirect fire support
- o Chemical support

- o Air support (close air support and attack helicopters)
- o Engineer support
- o Electronic warfare (EW) support
- o Combat service support

2.6.4 Collection of Decision-Making Information

The information for use in the application of the decision-making methodology is collected separately from the data transfer information; however, the video and audio recordings of exercise play remain the principal source of information. Additionally, the same military consultants would be used to extract and interpret the information from the tapes.

A decision collection form (Figure 2-14) was prepared and would be utilized to record decision-making information for analysis. The information in the heading of the form is entered as for the data collection form (paragraph 2.4.5). A brief explanation of the entries to be placed in the decision collection form is as follows:

Decision date-time - the exercise date and time for the completion of the decision announcement is entered. The entry should be identical to the end

CATTS DECISION COLLECTION FORM

UNIT _____ OBSERVER _____

DATE _____ EXERCISE DAY _____

SCENARIO FULDA _____ ATTACK _____ DELAY _____
 SNAI _____ DIVISION ATTACK _____ DEL INERATE DLFENSE _____
 IRWIN _____ COVERING FORCE _____ HASTY DLFENSE _____
 MOVEMENT TO CONTACT _____

PROBE NUMBER _____ PROBE DESCRIPTION _____

DECISION DATE - TIME				DECISION MAKER TO	DECISION COMPONENT													REMARKS					
					CONCEPT OF OPERATIONS	MISSION	MANEUVER UNIT	MISSION	MANEUVER UNIT	MISSION	MANEUVER UNIT	MISSION	MANEUVER UNIT	MISSION	MANEUVER UNIT	BATTALION ORG/H	CONTROL/COORD		(PL, ROUTES, ZONES, OBJ)	INSPECT FIRE	SUPPORT	CHEMICAL SUPPORT	AIR SUPPORT (CAS, AU)
DAY	HR	MIN	SEC																				

Figure 2-14. CATTS DECISION COLLECTION FORM

time for the corresponding entry on the CATTs data collection form.

Decision-maker ID - The radio call sign for the decision-maker is entered. Normally, the entry will identify the decision-maker as the commander; however, if another person is acting for the commander, enter the radio call sign for the other person.

Decision component - For every decision made, "x's" are placed in the appropriate decision component column to indicate the composition of the decision. Coded identities of the maneuver units are entered in the space provided.

Remarks - A number is placed in this column to cross reference the entry to remarks made on a separate paper. Remarks about the quality of the decision are not required.

2.6.5 Analysis of Decision-Making Information

Several key measures of decision-making performance, each of which may be obtained from interpretations of video and audio tapes, are necessary of quantification to support testing of those hypotheses listed in paragraph 2.6.2 above. These measures are identified as:

- o Decision rate
- o Decision components per decision
- o Decision component rate by type

These measures will not be quantified by data collected during the second contract year; therefore, discussions only of these measures and the anticipated results of the use of these measures in hypothesis testing are presented in the subparagraphs which follow. The basic assumption associated with all hypotheses is that the tactical scenarios are essentially constant and that the only independent variables are those expressed in the hypotheses. Considering the free play nature of CATTS exercise play, this assumption may become soft in its influence on the hypothesis testing. In each subparagraph below, cautions in the hypothesis testing are discussed to ensure that test results would be properly interpreted. The discussions indicate that the needed hypotheses may include multi-dimensional relationships which require that constraints be added to the testing problem. The hypotheses stated in paragraph 2.6.2 are initial hypotheses only and may need refinement based upon actual data collected. A

requirement for considerable sensitivity testing may also result.

2.6.5.1 Decision Rate

The decision rate hypothesis (Hypothesis D1 above) postulates a curvilinear relationship (inverted U) between the decision rate and combat effectiveness. Interpretation of results of testing this hypothesis must recognize the implied constants in this relationship; for example, the environment, the initial opposing force ratios, the task force organizations, and the military operation (covering force) involved. As the exercise unfolds with reasonable uniformity, the commander who makes too few decisions suffers reduced combat effectiveness. There is a point of inflection (maximum) at which the decision rate yields optimum combat effectiveness for the scenario being played, and beyond that point, any increase in the decision rate yields degraded combat effectiveness.

The free play nature of CATTs exercises will probably not support the assumption of scenario constants stated above; therefore, extreme care must be exercised in interpreting the results of hypothesis testing. As an example, a low decision rate could indicate an indecisiveness on the part of the battalion commander or possibly the lack of perception that a change in the original battle plan was necessary to take advantage of the

situation. Inaction on the part of the commander in these instances would result in low combat effectiveness and would be in keeping with the intent of the hypothesis as stated. On the other hand, a low decision rate could also imply that the original operation plan was extremely good and that adjustments to that plan were unnecessary to cope with the unfolding scenario; thus, high combat effectiveness would be achieved with little decision action on behalf of the latter battalion commander.

A corresponding anomaly may exist at the high decision rate end of the spectrum. A high decision rate could reveal a commander who overreacts to slight changes in the tactical situation which in turn leads to confusion and insufficient time or ability to respond on the part of subordinate commanders, a situation which yields reduced combat effectiveness. Equally reasonable of interpretation is the case where a high decision rate may be dictated by a rapidly changing situation wherein a commander who is quick and efficient in response to the changing situation will achieve high combat effectiveness.

The examples described above may present extreme cases; nonetheless, they illustrate the dangers of interpretations of correlations without considering major impacting factors and without benefit of a complete analysis. Finally, interpretations of limited samples of data may be insufficient to reveal whether the data are on the positive or the negative slope of the curvilinear

relationship; therefore, additional tests or data may be necessary to establish that fact.

2.6.5.2 Decision Component/Decision Ratios

The decision component hypothesis (Hypothesis D2 above) postulates a negative relationship between the ratio of decision components-to-decisions and combat effectiveness. The expected relationship indicates that a commander whose decision-making activities include a low decision component to decision ratio is probably fine-tuning an already good plan; whereas, the commander who is displaying a high ratio is probably making major changes to an operation plan which otherwise would not have accomplished the mission.

As was the case in analyzing decision rate data, care must also be exercised in the analysis of decision component/decision ratios. It is probable that decision rates and decision component/decision ratios should be considered together. For example, it is possible that a low decision rate, coupled with a high decision component/decision ratio, presents a case wherein a battalion commander allows a situation to build up and then makes a decision which is highly integrative of decision components, thus leading to high combat effectiveness. Correspondingly, a high decision rate coupled with a high decision component/decision ratio presents the case where in

the commander is making frequent and major changes to his operation plan which may yield low combat effectiveness.

2.6.5.3 Decision Component Rate

The decision component rate hypothesis (Hypothesis D3 above) postulates that there is a positive relationship between the rate of use of selected decision components to combat effectiveness. The decision rate hypothesis treats selected decision components individually and relates their use to combat effectiveness. As an example, a high rate of use of indirect fire support (primarily artillery) as a decision component may result in a major impact on battle outcome while the rare use of engineer support may have no effect. Obviously, the analysis should be made across a number of participating battalions having approximately the same quantity of resources available. As with other hypotheses, analysis of test results which reveal anomalies in the hypothesis should be examined carefully to seek major impacts by other variables.

2.7 HYPOTHESIS TESTING

Normally, hypotheses are tested as part of a move from the development of a theory, to the change of the theory, and eventually to the establishment of a scientific paradigm. The process from theory to revision has been

design - experimental treatments - statistics - parameter estimates - tests of hypotheses - revision of theory. The current research effort has limitations in experimental design (only observational, unobtrusive measures could be used) and in experimental treatments (all battalion command groups would receive the same treatment); therefore, hypotheses were developed which could be tested in the CATTS environment.

The current research effort has not been an attempt to provide definitive answers to theoretical questions but rather an attempt to develop behavior measures and to use these measures to relate behavior to overall command group effectiveness. Tests of hypotheses postulated in the research effort must be considered as evaluative of behavior exhibited in the CATTS environment rather than as predictive of command group effectiveness in actual combat. To the extent that hypotheses could be supported, the tests demonstrate relationships which may only exist within the framework of CATTS. To the extent that hypotheses are not supported, the results indicate only that the CATTS exercises do not show a significant relationship between the independent and dependent variables.

In all cases hypothesis testing is conducted using the Pearson Product Moment Correlation (Games and Klare, 1967). In all hypotheses, command group effectiveness (as measured by combat effectiveness) is the dependent variable. Independent variables have been selected to take advantage

of significant data transfer and staff process activity.

Since the current research effort is interested in both what may be affecting battle outcome, as well as what may not be affecting it, the traditional significance criterion convention of 0.05 level of significance can be altered so that the chance of a Type II error is decreased and the chance of a Type I error is increased. In keeping with this rationale, the significance level was set at 0.10. Results of hypothesis testing can be found in paragraph 3.3 below.

2.8 SUBJECTIVE ANALYSIS OF COMMAND GROUP BEHAVIOR

Early in the process of developing an initial methodology for evaluation of command group performance, SAI considered a more qualitative approach but deferred it in favor of the quantitative approach chosen. Quite a bit of effort was devoted to considering qualitative measures of command group behavior, to the extent of developing sets of such measures.

An opportunity for a subjective evaluation of battalion command group behavior presented itself during the TDS exercises, and the opportunity was seized. From a set of qualitative measures developed early in the second contract year, seven measures were selected as being most appropriate to a subjective evaluation of command group behavior, and a questionnaire was constructed (Figure 2-15).

PERFORMANCE MEASUREMENT

Science Applications, Inc., under contract to the Army Research Institute, is developing a methodology for evaluating battalion command group behavior using CATTS as a laboratory. To provide us with information related to command group behavior, but developed judgmentally (as distinguished from statistically), please perform the following evaluations.

A. Based upon the definitions of measures of performance below, evaluate how well the command group performed in each measurement category. Assign an evaluation score to each measure according to the following scale:

1	2	3	4	5	6	7	8	9
Poor		Fair		Good		Very Good		Outstanding

Measure Number	Definition	Evaluation Score
1	<u>Competence</u> - the degree to which individuals, staff sections, and the command group as a whole exhibited knowledge, training, and experience in the performance of assigned tasks.	_____
2	<u>Reliability</u> - the demonstrated degree of consistency by the command group for high quality performance at every opportunity.	_____
3	<u>Functional integrity</u> - the demonstrated degree of adherence by the command group to the performance of <u>assigned</u> staff functions (as contrasted with attempts to infringe upon the staff functioning of others).	_____
4	<u>Flexibility</u> - the demonstrated degree of freedom of planning and actions in response to change or stress.	_____
5	<u>Professional quality</u> - the degree to which the performance of staff processes conformed to established Army doctrine, policies, and procedures.	_____

Figure 2-15. PERFORMANCE MEASUREMENT QUESTIONNAIRE

<u>Measure Number</u>	<u>Definition</u>	<u>Evaluation Score</u>
6	<u>Personal demeanor</u> - the degree to which each staff officer and the command group as a whole practiced good interpersonal behavior.	_____
7	<u>Team awareness</u> - the degree to which individual performance was subordinated to staff section performance; the degree to which staff section performance was subordinated to command group performance.	_____

B. Based upon your evaluations in paragraph A above, evaluate overall command group performance using the same scale (i.e., 1-9). _____

C. Based upon your professional judgment, arrange the seven measurement categories in their order of their importance to an evaluation of overall command group performance

<u>Ranking</u>	<u>Measurement Number</u>
1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____

Figure 2-15. PERFORMANCE MEASUREMENT QUESTIONNAIRE (concluded)

The questionnaire was administered both to the CATTS Chief Controller and to the SAI consultant who classified each battalion command group's activities. The results of this subjective analysis are presented in paragraph 3.3.3.4.

2.9 PROBE DESIGN AND APPLICATION

The design of a probe system to make it possible to capture more relevant behavior, behavior that would be stimulated by presenting various challenges to the battalion command group or its individual members, was focused around the CATTS exercise play. Using the probe system(s), it would be possible to extract information which would permit detailed behavioral analysis of highly controlled portions of the exercises. These probes would be designed and developed to permit comparison of command group performance across all exercises, regardless of unit task organization, geographical environment, and unit mission: hence, an in-depth behavioral analysis across different groups in similar situations would be possible. Additionally, the development of such probes should serve as a guide for future probe design and application.

2.9.1 Probe Description

A probe is a method of controlling inputs into a system and of recovering useful data pertaining to actions

and reactions to the inputs. Probes used in conjunction with CATTS exercises, or similar simulations, will introduce unanticipated (by the players) changes in the tactical situation or will impose other stress situations upon the battalion command group. Reaction behaviors will be carefully recorded on video and audio tapes to permit detailed analysis. The analysis is performed using the same methodology as for other command group behavior.

A wide variety of probes are candidates for use depending predominantly on the character of the simulated military operation but also considering the environment and the task organization of the simulated maneuver unit. The following is a sample of probe scenarios:

- o Unusually heavy enemy artillery or air attack
- o Unanticipated contact with the enemy
- o Encountering unexpected obstacles (e.g., minefields)
- o Commitment of enemy second echelon forces
- o Sudden and significant friendly casualties
- o Loss of significant combat service support
- o Enemy electronic warfare (e.g., jamming)
- o Unusually heavy communications traffic

into the battalion TOC

- o Simulated death of a key command group player (e.g., battalion commander)
- o Enemy use of chemical warfare
- o Enemy nuclear attack

2.9.2 Probe Design

CATTS is a computer-assisted simulation which permits free exercise play on the part of both the players and the controllers. The scenario varies across simulated task force organization, mission, and environment; however, replications of similar scenarios by different battalion command groups are conducted and controlled with reasonable operational similarity. Probe design must consider all three scenario components (organization, mission, and environment), but most importantly must consider the objective(s) to be achieved by insertion of the probe. A probe designed for one military operation may not be credible or useful for a different military operation. Probe objectives may include one or more of the following:

- o Analysis of the response behavior of a selected staff section in the performance of its function
- o Analysis of the response behavior of the command group, including the commander and all staff sections in exercising command and control

- o Analysis of behavioral responses to a variety of stimuli
- o Analysis of different behavioral response to a single stimulus

A probe demands input which will require the command group, individually and collectively, to assemble and properly interpret information and to react to the probe. The design and application of a probe must be well disciplined if interpretable results are to be acquired.

Probe design may be evolved using either of two basic techniques; namely;

- (1) The identification within the simulation scenario of the battle situation which has the potential for achieving the probe objectives. The identified situation would then be the focus of probe design insofar as applying the necessary discipline is concerned.
- (2) In keeping with the probe objectives, design a probe which may be inserted on an ad hoc basis independent of the specific scenario but triggered by a scenario event. Insertion of such a probe into exercise play would be at the discretion of the chief controller; nevertheless, it would be strongly disciplined.

Recognizing the free play nature of CATTS simulation exercises, SAI opted to design its probes in conformance with the latter technique; ad hoc probes.

In designing a probe, it is of paramount importance to identify the objective(s) of the probe. Such identification will not only provide the basis for probe development but will also permit evaluation of command group behavior in reaction to the probe. Once the probe objective is established, the following requirements for insertion and disciplining the probe are necessary.

- o Probe description
- o Specification of the media for insertion (e.g., radio, telephone, message)
- o Development of the initial and subsequent specific information to be inserted to fully build up the probe scenario, the events which trigger the insertion of the information, the controller who is to introduce the information, and the battalion command group member who is to receive the information.
- o Development of the responses by controllers to ad hoc queries from the command group so as to support probe play
- o Identification and description of anticipated and/or desirable reactions to the probe by the command group

- o Specification of exercise events which will govern termination of probe play
- o Criteria by which command group reaction to the probe is to be evaluated.

2.9.3 Pilot Probes

During the second contract year SAI developed two pilot probes to assist in the development of the methodology for probe design. The geographical area of the National Training Center (Fort Irwin) was used for both probes. One probe was inserted during the attack scenario while the other was inserted during the covering force scenario.

The objective of the pilot probe used in the attack scenario was to evaluate the actions of the battalion S3 section upon receipt of information of a downed enemy troop-carrying helicopter in the battalion sector. Subobjectives included the extent of intra-command group coordination (particularly with the S2); the distribution of the information to interested command group members, principally the commander; the extent of activity to verify the information and to expand upon the information base; and overall reaction of the staff to the probe. The probe information was input by a company commander controller to the battalion S3, and in all three cases of probe insertion no further action by the battalion command group ensued.

The objective of the pilot probe used in the covering force scenario was to evaluate the actions of the battalion S2 and of the command group upon receipt of information that an enemy tank force was present on an exposed flank of the battalion. Subobjectives included the extent of intra-command group coordination; the distribution of the information; the extent of activity to verify the information; and the overall reaction to the probe. The probe information was input by the brigade S2 controller to the battalion S2, and in all cases the information drew rapid reaction on the part of the battalion S2. The information was evaluated to indicate that an enemy tank force constituted a threat to the exercise battalion, was distributed rapidly to the battalion commander and to subordinate units, prompted tactical plans to cope with the threat, and in some cases resulted in overt action to counter the threat. Actions to terminate the probe were initiated in all cases before force engagement ensued.

The use of these pilot probes, and the analysis and evaluation of the results of their use, served to confirm the probe design philosophy being followed and resulted in the following lessons learned, all of which influenced formal probe design:

- o Probes must be carefully designed, inserted, and developed if useful results are to be realized.
- o Probe scenarios must be credible on the part of the battalion command group and

must be consistent with the exercise being played.

- o Probe scenarios must present significant change or impose stress on the battalion command group if reactions are to be evoked.
- o Probe scenarios must be developed so that the probe is not recognized by the players as such but is perceived as being integral to the exercise scenario.
- o Probe reactions beyond the organizational and doctrinal missions or beyond the normal experience and state of training of the battalion command group should not be expected and should not be embodied in probes for CATTS application. (The downed helicopter probe appears to be overly sophisticated for application at battalion level).

SAI's pilot probes were inserted into those CATTS exercises which were not integral to ARI's Training Development Study; therefore, detailed data collection and objective analysis of probe results were not possible. Maximum effort was exerted to avoid jeopardizing TDS results with scenario perturbations which might bias study results.

2.9.4 Probes to Evaluate Command Group Behavior

Based upon experience gained during contract performance for the first and second contract years, SAI has designed two probes for application during battalion command group participation in CATTS simulation exercises. It is believed that a series of such scenario-dependent (e.g., attack, delay, covering force) probes will be necessary to provide the quantity of behavior information needed for meaningful analysis. The objectives and the general nature of the probes are discussed in the subparagraphs which follow. These probes are the result of design activities and have not yet been applied to a CATTS exercise; however, SAI has extremely high confidence that they can be applied to achieve the objectives stated. Detailed information regarding these probes appears in Appendix E, Probe Designs.

2.9.4.1 Probe Design I - Delay Scenario

The objective of this probe is to evaluate the actions of the S2 and his staff after receiving information of enemy activity outside of sector that could affect the battalion's maneuver units. The probe consists of several messages identifying and locating an enemy tank platoon south of the battalion sector moving in a northerly direction. Their continued movement could result in an attack of the battalion flank that could seriously affect the unit's defensive mission. The action takes place in the

Ft. Irwin scenario during a covering force operation. It is terminated when the enemy tank platoon reverses direction and is no longer a threat.

2.9.4.2 Probe Design II - Attack Scenario

The objective of Probe II is to analyze the behavior of the command group, including the commander, in responding to an unanticipated battle event. It is inserted into an attack operation in the Fulda Gap area of Germany. A maneuver company in the southern part of sector has encountered an unanticipated minefield which has stopped their forward progress. It is too time-consuming to attempt a breaching operation. There is a large city immediately to their north that inhibits a bypass in that direction. The desired reaction to the probe is to request permission to leave the sector in an attempt to bypass to the south. The probe terminates with permission granted and a successful bypass.

2.10 COMBAT EFFECTIVENESS DETERMINATION

Combat effectiveness, as measured by battle outcome, is strongly dependent upon the relative combat power of opposing forces and upon the effective application of such combat power. In the CATTS simulation exercises, command group effectiveness is a major component of the

application of combat power (see paragraph 2.2); therefore, the initial methodology relates command group effectiveness directly with battle outcome.

Combat power is the military force potential which one force has available to apply against his opponent in the accomplishment of an assigned mission. No precise measurement of aggregate force combat potential exists; therefore, one must rely upon notional concepts for such aggregation. One such notional concept is to sum the force potential using weighted values for each major constituent element of the force, including personnel and equipment. In CATTS exercises, the unit of measure for deriving force combat potential is the universal battle equivalent (UBE), and a UBE value is assigned to each significant component of the force. Similar items of opposing force personnel and equipment are assigned similarly quantified UBE. The force potential of each force is then determined by multiplying the quantity of the component of the force by its weighted value (in UBES) and then summing over all force components. These weighted values (UBE) are then used for measuring battle outcome as explained below. UBE values assigned to each force component for CATTS exercises are shown in Table 2-4. A sample calculation of relative combat potential for two opposing forces is shown in Appendix F , Figure F-6.

In the calculation of combat potential of opposing forces for application of the initial methodology, care has been exercised to constitute opposing forces such that force

Table 2-4. UNIVERSAL BATTLE EQUIVALENTS

UBE	Blue	Equipment Type	Red	UBE
2	M16	RIFLE	AKM	2
5	7.62MM	LMG	7.62MM	5
6	7.62MM	LMG, MOUNTED		
16	50 CAL	HMG		
2	LAW	AT MSL	SPG9	14
39	DRAGON	AT MSL	RPG7	17
37	TOW	AT MSL	SAGGER	20
45	TOW-113	APC/MSL	BRDM	36
		APC/MSL	BMP	38
19	M113	APC	BRDM	23
		APC	BMP	30
		APC	BTR-60	20
73	M60A1	TANK	T-62	80
80	M60A2	TANK	T-72	86
30	M125A1-81MM	MORTAR	100MM	25
32	M106A1-107MM	MORTAR	120MM	35
25	VULCAN	ANTIAIR	ZSU-23,57DUAL	25
		MRL	BM-21	37
37	M109	HOWITZER	122MM	33
38	M110A1	HOWITZER	152MM	37
32	M102	HOWITZER	130MM	36
		LONG RNG MSL	SCUD, FROG	40
1	TRUCK	TRUCK/ALL PURPOSE	TRUCK	1

differentials of combat power are represented by like type components. As an example, if one force is constituted of maneuver units only, then the opposing force is constituted of maneuver units only. Correspondingly, if one force is constituted with maneuver units and artillery then the opposing force is similarly constituted. Since force components inflict and suffer casualties at differing rates the application of this basic rule permits battle outcome to be effectively analyzed.

Combat potential at the beginning of exercise play is referred to as initial strength and at the end of play as ending strength. The period of play may extend from the beginning to end of an entire exercise scenario, or may include only the time span of a particular period of interest. Battle outcomes are determined by one or more mathematical manipulations of initial and ending strengths.

There are several measures of battle outcome accepted by USA TRADOC which were considered for application in the initial methodology. They are:

Loss exchange ratio (LER) - the ratio of enemy losses to friendly losses over a common battle duration.

Relative loss exchange ratio (RER) - the ratio of percent of enemy losses to the percent of friendly losses over a common battle duration.

Surviving maneuver force ratio

differential (SMFRD) - the percent of friendly force surviving minus the percent of enemy force surviving over a common battle duration.

A 1982 study of CATTS exercises (Thomas, 1982) showed that RER and SMFRD correlated most closely with CATTS controller personnel's subjective perception of how well the battalion command group performed in the simulation exercise. The data collected during the current project indicated that all three combat effectiveness measures correlated quite highly as shown in Table 2-5; therefore, one measure, relative loss exchange ratio (RER), was selected by SAI for use in application of the initial methodology. The RER is a measure of force effectiveness taking two major factors into consideration; the numerator of the ratio is an indicator of force destructive capability while the denominator is an indicator of force survivability. The combination is an overall indicator of combat effectiveness.

Table 2-5. CORRELATIONS OF COMBAT EFFECTIVENESS MEASURES

MEASURES	RER	LER	SMFRD
RER	1.0000	.9966	.9643
LER		1.0000	.9529
SMFRD			1.0000

SECTION 3

RESULTS AND DISCUSSION

This section reports the results obtained from the application of the initial methodology to data derived from instrumentation of the CATTS facility and from the analysis of the data in order to evaluate battalion command group behavior.

3.1 GENERAL

There is little systematic knowledge about the complex human behavior of battalion command groups and about the impact which that behavior has upon command group effectiveness. This research effort is an attempt to study empirically the behavior of such groups in an instrumented, though not controlled, environment and to derive some relationships between the behavior and battle outcome. Such knowledge will provide insight into the more influential staff behaviors; will permit an understanding of the patterns by which staff individual behaviors are integrated

and aggregated into effective team performance, will hopefully lead to more effective training of command groups, and optimally, may contribute to better management of those military resources concerned directly with land combat operations. This section concentrates on the evaluative and descriptive aspects growing out of data recorded and interpreted as a limited number of battalion command groups participated in CATTS simulation exercises.

The analytical results achieved during the second contract year and reported in this section are the product of the development of an initial methodology for evaluating battalion command group behavior, the instrumentation of the CATTS facility to record data relating to simulation exercise play, the interpretation of the data for use with the methodology, and the application of both statistical and judgmental techniques to analyze the data to determine the contribution of staff behavior to command group effectiveness.

The results of the application of analytical techniques to both reliability and hypothesis testing are reported in the subparagraphs which follow.

The aggregate of all TDS exercise information classified by three military consultants was used to analyze, evaluate, and compare the command group effectiveness of ten battalion command groups; therefore, testing of the reliability of the consultants to interpret and classify command group behavior was both desirable and necessary (see paragraph 2.4.4 above).

As a precursor to classification activities and in an attempt to establish an acceptable level of reliability for classifying command group behavior, an initial set of rules for such classification was developed. As the consulting military experts began their work, each was given an opportunity to familiarize himself with the analytical requirement and with the operation of video and audio equipment which would be used to view, interpret, and classify command group behavior. The ground rules for classification of behavior were explained and discussed with the group individually as well as collectively. Interpretation and classification of recorded information was then practiced by each consultant and was critiqued by the project leader. A refinement of classification procedures and rules followed.

The military consultants were then asked to classify a common period of a previously recorded battalion command group exercise. The behavior classifications by the consultants were carefully evaluated, and the procedures and

rules for classifying command group behavior were again refined. The rules were thoroughly discussed in group session to ensure an understanding by each consultant. Where necessary, the rules were explained by reference to a specific video or audio recording.

Available contract resources did not permit either a more expansive training period for the consultants to achieve optimum uniformity of interpreting command group behavior or the replication of interpretation of the exercises by more than one consultant.

At this point in time, a reliability test for record was conducted by having each consultant interpret and classify data from a common TDS exercise scenario. Although the data transfers, communication modes, staff behavior, and staff processes were classified at node (individual staff member) level, reliability tests were run at aggregate level using analysis of variance techniques.

Interobserver reliabilities of behavior classifications by the three military consultants were estimated for the observational measures which are used to test hypotheses postulated in Section 2. The observational measures are defined in the methodology and are based upon data taken from the video and audio recordings. For each classification category (data transfer, communication mode, staff behavior, and staff process) the minimum, maximum, mean, standard deviation, and reliability are reported in Table 3-1.

Table 3-1. RELIABILITY ESTIMATES

VARIABLE	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION	RELIABILITY
<u>DATA TRANSFER</u>					
Data Transfer Frequency	6.57	19.70	13.22	4.23	.70
Data Transfer Duration Ratio	2.89	5.78	4.42	0.99	.60
<u>COMMUNICATION MODE</u>					
Telephone Frequency	0.08	0.99	0.52	0.27	.54
Telephone Duration Ratio	0.08	0.70	0.35	0.17	.86
Radio Frequency	1.33	4.90	2.60	1.09	.68
Radio Duration Ratio	0.76	2.41	1.19	0.52	.76
Face-to-face Frequency	4.66	15.80	9.28	3.62	.68
Face-to-face Duration Ratio	1.72	4.21	2.74	1.81	.43
<u>STAFF BEHAVIOR</u>					
IMI Frequency	0.91	5.36	2.97	1.59	.42
IMI Duration Ratio	0.37	1.40	0.96	0.33	.41
Team Frequency	3.06	6.66	4.95	1.10	.58
Team Duration Ratio	1.49	2.64	1.97	0.45	.73
<u>STAFF PROCESSES</u>					
Seeking Info Frequency	0.23	2.71	1.47	0.76	.68
Seeking Info Duration Ratio	0.07	0.87	0.45	0.28	.58
Receiving Info Frequency	0.71	1.67	1.01	0.28	.52
Receiving Info Duration Ratio	0.36	0.60	0.43	0.08	.72
Coordinating Frequency	0.88	5.22	2.64	1.80	.19
Coordinating Duration Ratio	0.42	1.73	1.05	0.42	.31
Transmitting Info Frequency	0.62	2.24	1.66	0.49	.48
Transmitting Info Duration Ratio	0.31	0.98	0.51	0.21	.39
Assessing Situation Frequency	0.08	1.35	0.46	0.47	.12
Assessing Situation Duration Ratio	0.00	0.74	0.31	0.23	.10
Total Processes Frequency	4.20	11.30	7.92	2.33	.64
Total Processes Duration Ratio	1.99	3.79	2.93	0.61	.56

With an acceptable reliability level of 0.70, the information in Table 3-1 indicates a general lack of reliability of the military consultants to commonly classify the data observed. This reliability test was conducted with a very small sample of data at a time when the consultants had conducted only a limited amount of data classification. Although the classification rules were fine-tuned and considerable classification experience was gained over the total observation period, a final reliability test was not conducted after classifications of all exercises were completed. Such a final reliability test would have revealed the extent to which reliability of classifications had increased.

Reliability of the consultants to classify command group behavior can be improved by the establishment of more definitive classification rules, by more extensive training in the application of the rules to exercise recordings, and by constructive critiques of classification activities prior to future behavior classification. Reliability of classification may also be enhanced by improving the laboratory environment by such artifices as improved lighting, more extensive instrumentation (e.g., cordless microphones on each key player), player identification markings (e.g., armbands or similar identification devices), improved video recording systems, and more effective control of the exercise for research purposes.

3.3 HYPOTHESIS TESTING

Hypothesis testing was conducted both statistically and judgmentally. Statistical tests may not reveal anomalies of data and relationships which judgmental analyses may expose; therefore, both analytical approaches were used in application of the initial methodology. The hypotheses tested are those postulated in Section 2.

3.3.1 Battle Outcome

The principal dependent measure in the initial methodology is battle outcome, or combat effectiveness. There was some question about choosing the measure of battle outcome to be used in initial methodology for hypothesis testing; therefore, correlations among candidate measures were conducted. The analysis of these battle outcome scores using the candidate measures showed high correlations (Table 3-2); therefore, the relative loss exchange ratio was selected as the battle outcome measure (see paragraph 2.10 for methodology discussion and for definitions of measures).

3.3.2 Statistical Tests

Statistical tests (Pearson Product Moment Correlation) of hypotheses were conducted using computer programs integral to SPSS (Nie, et al, 1975), which is operational on the UNIVAC 1100 System at the Data Processing

Table 3-2. BATTLE OUTCOME CORRELATIONS

MEASURES	RER	LER	SMFRD	RER(A) ¹	LER(A) ¹	SMFRD(A) ¹
RER	1.0000	.9966	.9643	.9889	.9877	.9686
LER		1.0000	.9529	.9817	.9886	.9643
SMFRD			1.0000	.9679	.9589	.9918
RER(A) ¹				1.0000	.9948	.9720
LER(A) ¹					1.0000	.9711
SMFRD(A) ¹						1.0000

¹Includes artillery in OPFOR units only.

Field Office, Fort Leavenworth, Kansas. The measures (variables) integral to each hypothesis were correlated with battle outcome (relative loss exchange ratio) for the ten TDS exercises, and the results are displayed in Table 3-3. The statistical test results showed only a single instance of correlation significance between the variables and battle outcome when using an alpha level of 0.10.

3.3.3 Judgmental Analyses

The exploratory nature of the current research efforts next led the project team to a subjective analysis of the TDS simulation exercises. The objective of this analysis was to produce meaningful interpretations of results data, and the main thrust was to relate the results of the ten independent data sets to overall command group behavior as well as to battle outcome. The nature of the ARI Training Development Study also permitted observations of pairs of exercise results where the exercises of interest were the first and fourth exercises of a four exercise set, each pair being conducted by the same battalion command group. Judgmental analysis considered the results data, first, as if there were ten independent exercises and, second, as paired exercises of five different command groups. In the case of paired exercises, only limited observations were made since the Army Research Institute is treating the subject extensively under a separate research effort.

Table 3-3. STATISTICAL CORRELATIONS

VARIABLE	RELIABILITY	CORRELATION WITH RER	SIGNIFICANCE
<u>DATA TRANSFER</u>			
Data Transfer Frequency	.70	.10	.38
Data Transfer Duration Ratio	.60	-.10	.39
<u>COMMUNICATION MODE</u>			
Telephone Frequency	.54	.21	.28
Telephone Duration Ratio	.86	-.05	.45
Radio Frequency	.68	.03	.46
Radio Duration Ratio	.76	-.16	.33
Face-to-face Frequency	.68	.13	.36
Face-to-face Duration Ratio	.43	.05	.44
<u>STAFF BEHAVIOR</u>			
IMI Frequency	.42	-.00	.49
IMI Duration Ratio	.41	-.08	.41
Team Frequency	.58	.22	.26
Team Ratio	.73	-.15	.34
<u>STAFF PROCESSES</u>			
Seeking Info Frequency	.68	.04	.46
Seeking Info Duration Ratio	.58	-.09	.41
Receiving Info Frequency	.52	-.19	.30
Receiving Info Duration Ratio	.72	-.52	.06
Coordinating Frequency	.19	.08	.41
Coordinating Duration Ratio	.31	.00	.50
Transmitting Info Frequency	.48	.07	.42
Transmitting Info Duration Ratio	.39	-.25	.23
Assessing Situation Frequency	.12	.16	.32
Assessing Situation Duration Ratio	.10	.33	.17
Total Processes Frequency	.64	.10	.38
Total Processes Duration Ratio	.56	-.06	.43

Graphs of selected measures of staff behavior versus battle outcome were prepared to assist in judgmental analyses of data relating to data transfers, communications modes, and staff processes. The graphs displayed visually the data which were used to perform the statistical tests. Although graphs of behavior versus battle outcome for all hypotheses were prepared, only those from which meaningful interpretations were made are included in this report.

3.3.3.1 Data Transfers Versus Battle Outcome

Total data transfer frequency and duration ratio are measures of the activity level of the battalion command group in the conduct of the simulation exercise. The statistical analyses (paragraph 3.3.2) revealed no correlation between total data transfers (staff activity) and battle outcome. Figure 3-1 is a typical graph and confirms the lack of statistical correlation. The lack of correlation between total data transfer activity and battle outcome suggests that the CATTS simulation may not be sensitive to the level of activity of the participating command group, either in the design of the simulation model and/or the manner in which it is controlled and applied. It also suggests that staff activity levels may have little to do with success on the battlefield.

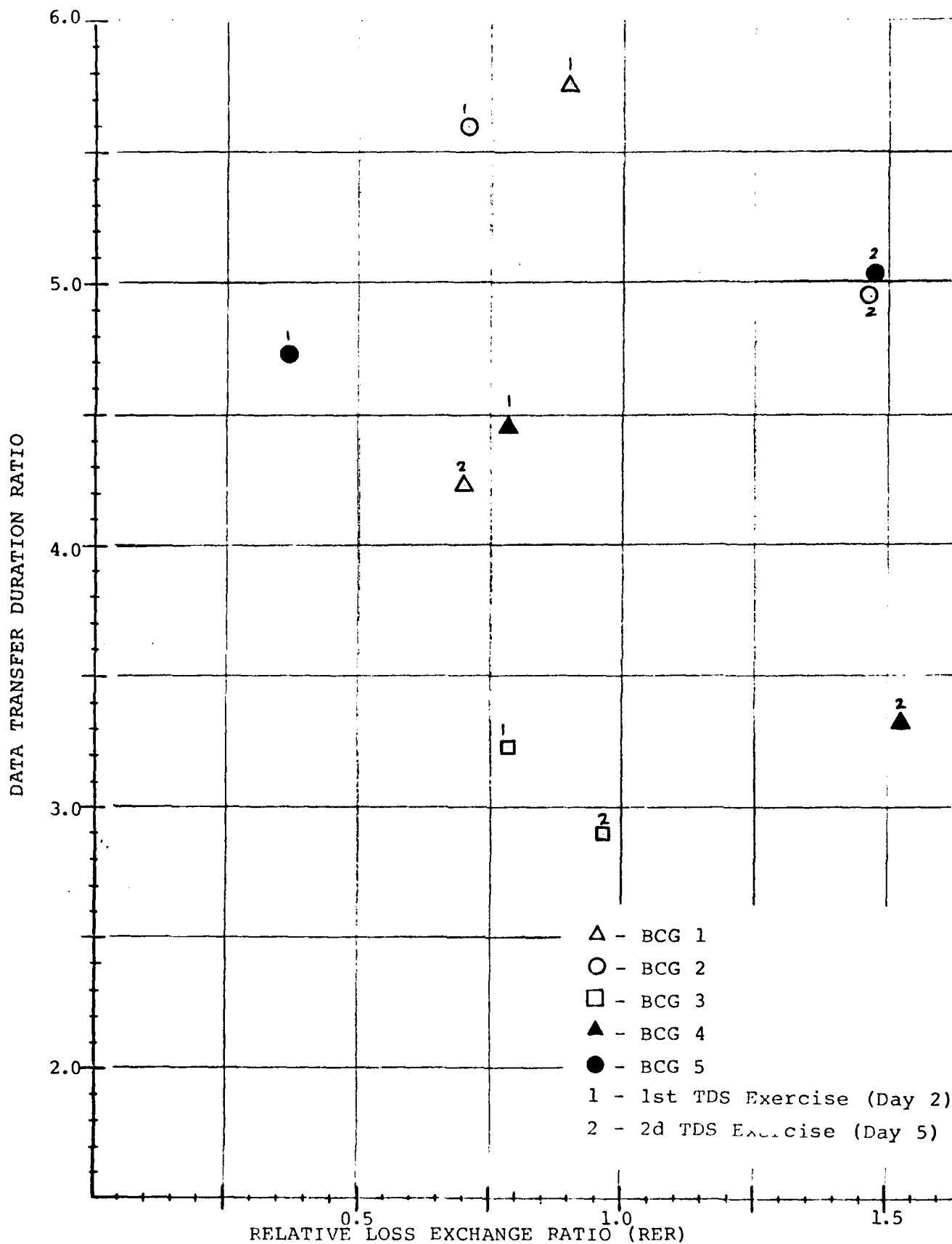


Figure 3-1. DATA TRANSFER VERSUS BATTLE OUTCOME

The battalion command groups actively participating in the exercises (as distinguished from unit-supplied controller personnel, such as company commanders) varied in size from 14 to 25. The differences in staff size might suggest considerable variation in data transfer frequencies and duration ratios; however, variations were not consistent with staff size.

Data transfer frequency and duration ratios were then analyzed in two categories: namely,

- o Intra-command group, which embraces intra-staff section as well as inter-staff section data transfers. This category was dominated by face-to-face communications even though limited written and electronic communications were present.
- o Extra-command group, which includes data transfers which take place between the command group and higher, subordinate, supporting, and adjacent units. These data transfers were dominated by electronic communication (radio and telephone, but principally radio) and represent communications between the command group and the controllers.

Intra-command group and extra-command group dyadic activities of a battalion command group for a typical TDS exercise are displayed in Figure 3-2. In the figure, data transfers displayed between the dashed lines are intra-section data transfers and represent individual/multi-individual behavior. All other intra-command group data transfers, as well as all extra-command group data transfers, represent team behavior. Analysis of information in Figure 3-2, and in similar figures for other exercises, leads to the following judgments:

- o The majority of the data transfers were accounted for by the battalion commander, the S3 Section, and the controllers (representing higher, lower, adjacent, and supporting units). From this observation it may be deduced (1) that battalion command group behavior in simulated (and possibly in actual) combat operations is dominated by the battalion commander and the operations (S3) section to the virtual exclusion of the others, or (2) that CATTS as a combat simulation is not structured and operated to permit realistic S1, S2, and S4 participation in exercise play.

RECEIVER

INTRA-COMMAND GROUP

	CO	S1	S2	S3	S4	HHQ	ADJ	LOWR	SUPT
CO	0	0	16	110	0	4	0	40	0
S1	0	30	2	1	28	9	0	16	0
S2	4	0	54	66	0	32	0	0	0
S3	80	0	57	268	0	44	0	65	17
S4	0	30	0	0	19	9	0	5	0
HHQ	0	4	13	32	2	0	0	1	0
ADJ	0	0	0	0	0	0	0	0	0
LOWR	44	18	4	107	20	3	0	9	0
SUPT	0	0	0	4	0	0	0	0	0

EXTRA-COMMAND GROUP

Figure 3-2. DYADIC ACTIVITY SUMMARY

- o The S1 and the S4 coordinated infrequently, if at all, with the battalion commander, S2 Section, or S3 Section, and vice versa. While this paucity of data transfer could be accounted for in part by the non-collocation of the staff sections (battalion trains versus TOC/jump TOC), it is another direct reflection of minimal participation of the S1 and the S4 in exercise play and of the limited contribution which they make to simulated battle outcome. It may also be a reflection of the degree to which the battalion commander optimizes the use of his entire staff in conducting and supervising operations. The S1 and S4 did coordinate frequently with each other, probably due in part to their collocation in the battalion trains area and in part to the interrelationship of their combat service support roles.
- o The limited S1 and S4 participation, and to some extent the S2 participation, in simulation exercise play may have a more subtle interpretation; namely, that the staff organization at battalion level may not be optimal for the planning,

direction, and supervision of battalion combat operations.

- o No coordination between the battalion command group and adjacent units was observed during exercise play, a critical omission during actual combat operations. This lack of coordination could be attributed either to a staff deficiency by the command group or to an intentional or unintentional omission from exercise play by controllers, or both.

The project team also examined the data transfer information for the pairs of exercises performed by each command group. Graphs of interest are presented in Figure 3-1 (total data transfer) and Figure 3-3 (radio mode). An analysis of Figure 3-1 reveals that for four of the five battalion command groups duration ratios for total data transfers decreased between the first and second TDS exercises, and for the fifth group there was only a slight increase. The general decrease in duration ratios was not analyzed in detail but could be attributed to one or a combination of the following:

- o Improved efficiency of command and control operations based upon staff functional experience (training) gained from four days participation in CATTS exercises; better knowledge of staff

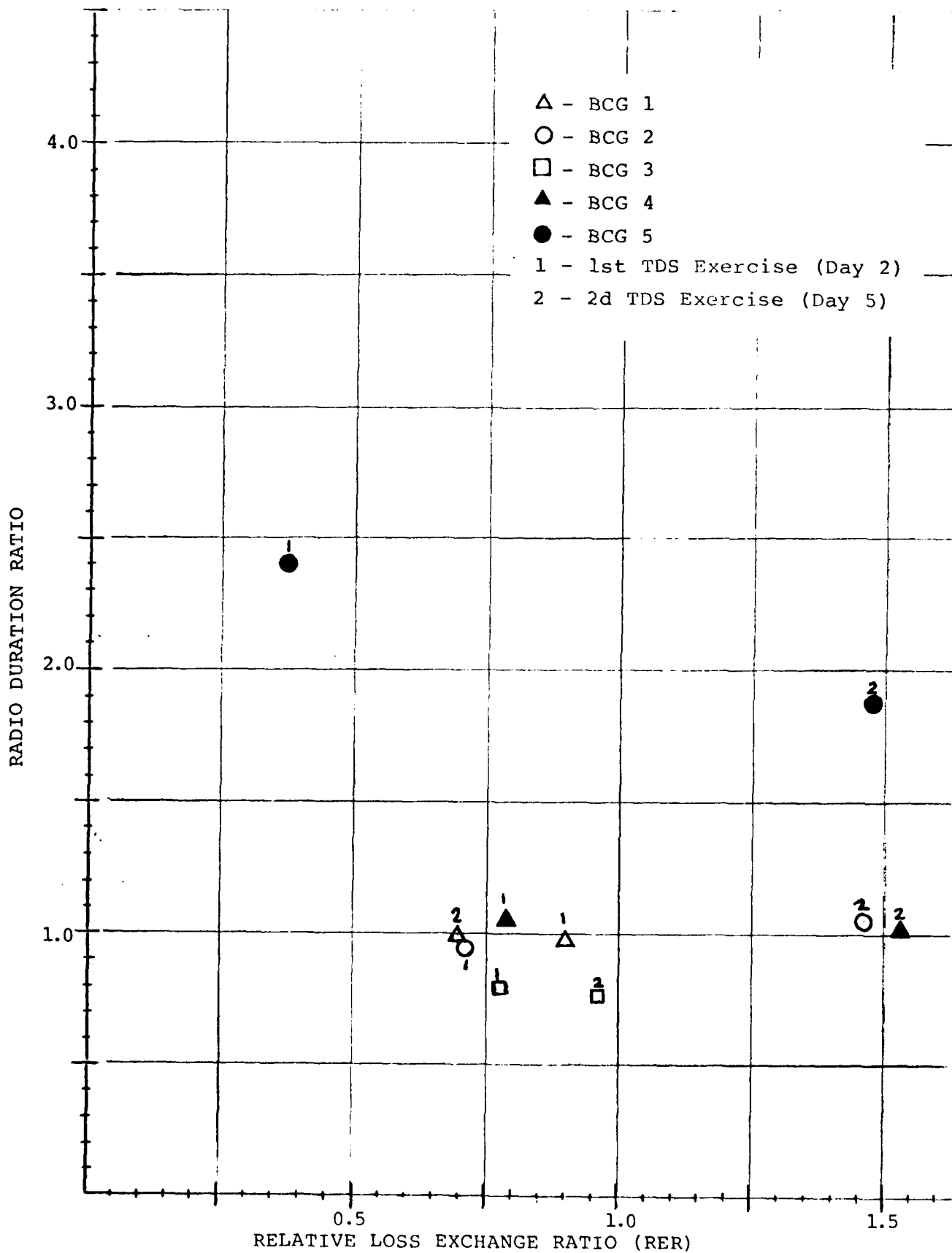


Figure 3-3. RADIO COMMUNICATIONS VERSUS BATTLE OUTCOME
3-18

roles to be played.

- o Improvement in, or better adherence to, standard operating procedures.
- o Learning to better play the simulation exercise and thus take advantage of simulation characteristics.
- o Improvement in capabilities to communicate effectively.

A significant observation and judgment is made from an analysis of Figure 3-3. Except for one anomalous instance, the radio duration ratio was relatively constant for all exercises and appears to indicate that the quantity of information supplied by the controllers (including company commanders) to the command groups is uniform and does not influence battle outcome. The quality of controller-input data, coupled with the use of the data once supplied, would appear to be the target for future analysis.

3.3.3.2 Staff Behavior versus Battle Outcome

Individual/multi-individual and team staff behavior are measures which could indicate the degree to which intra-staff section behavior (personnel, intelligence, operations, and logistics) and inter-staff section behavior contribute to battle outcome. The statistical analysis (paragraph 3.3.2) revealed no correlation between individual and team behavior and battle outcome, and graphs plotted by

team members confirmed the lack of statistical correlation. The graph of team duration ratio versus battle outcome for the ten TDS exercises, a typical behavior graph, is shown in Figure 3-4.

One significant observation is derived from a comparison of the mean duration ratios for individual and team behavior between the first and fourth exercise days for the five command groups. The mean duration ratio comparison for team versus individual behavior for the first exercise showed a relationship of 2.05:1, while the same comparison for the second exercise showed a relationship of 2.03:1. The constancy of this relationship shows that the duration of team behavior to individual behavior is probably on the order of 2:1. While this ratio could have been derived from an analysis of the aggregate of the ten exercises, the fact that the ratio held for both the first and fourth exercise days lends credence to the relative contribution of the behaviors to total staff activity.

3.3.3.3 Processes Versus Battle Outcome

Analysis of the frequency and duration ratio of staff processes supports an understanding of the degree to which such processes contribute to battle outcome. The statistical analysis (paragraph 3.3.2) revealed no correlation between total process performance and battle outcome, and Figure 3-5 makes apparent the lack of

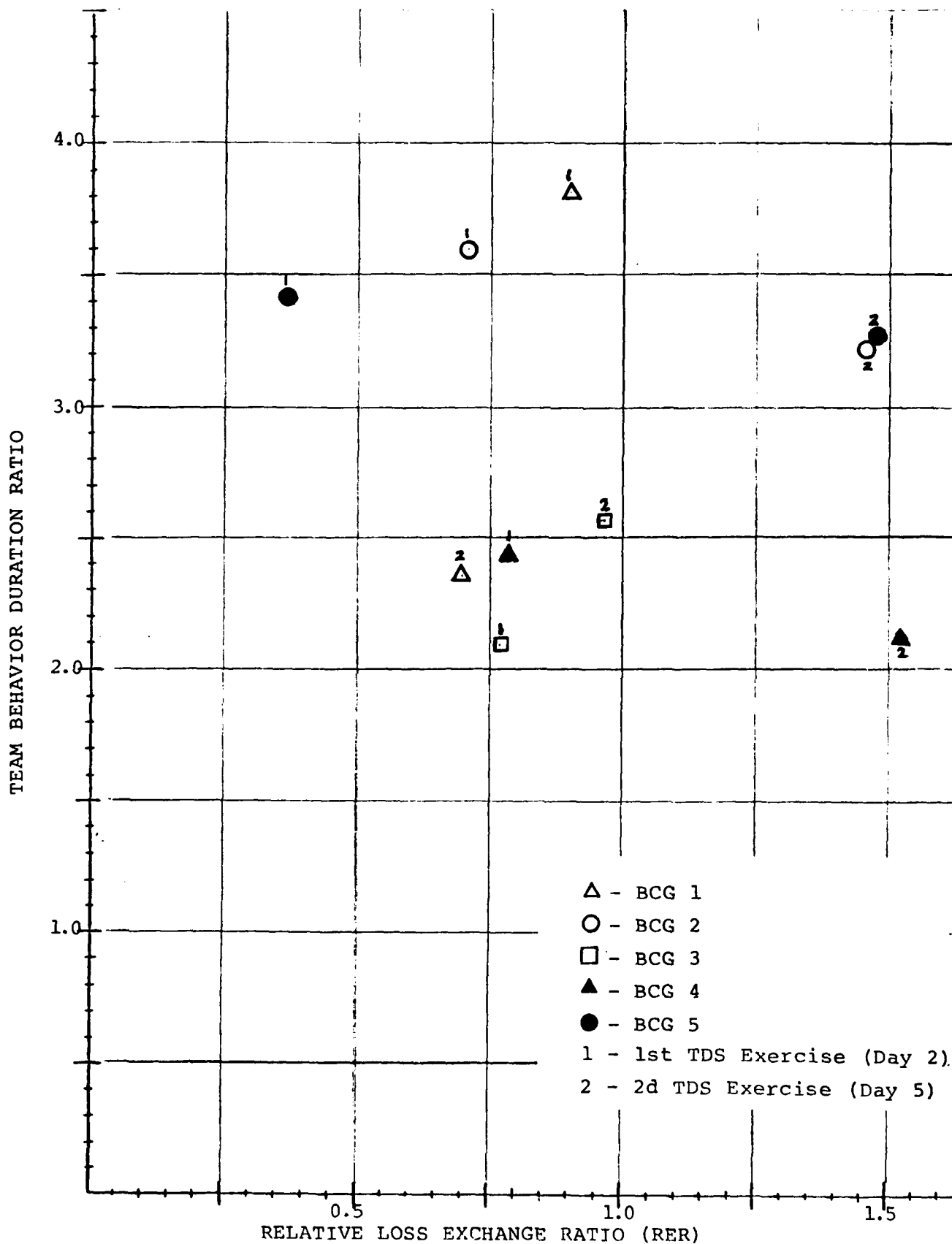


Figure 3-4. TEAM BEHAVIOR VERSUS BATTLE OUTCOME
3-21

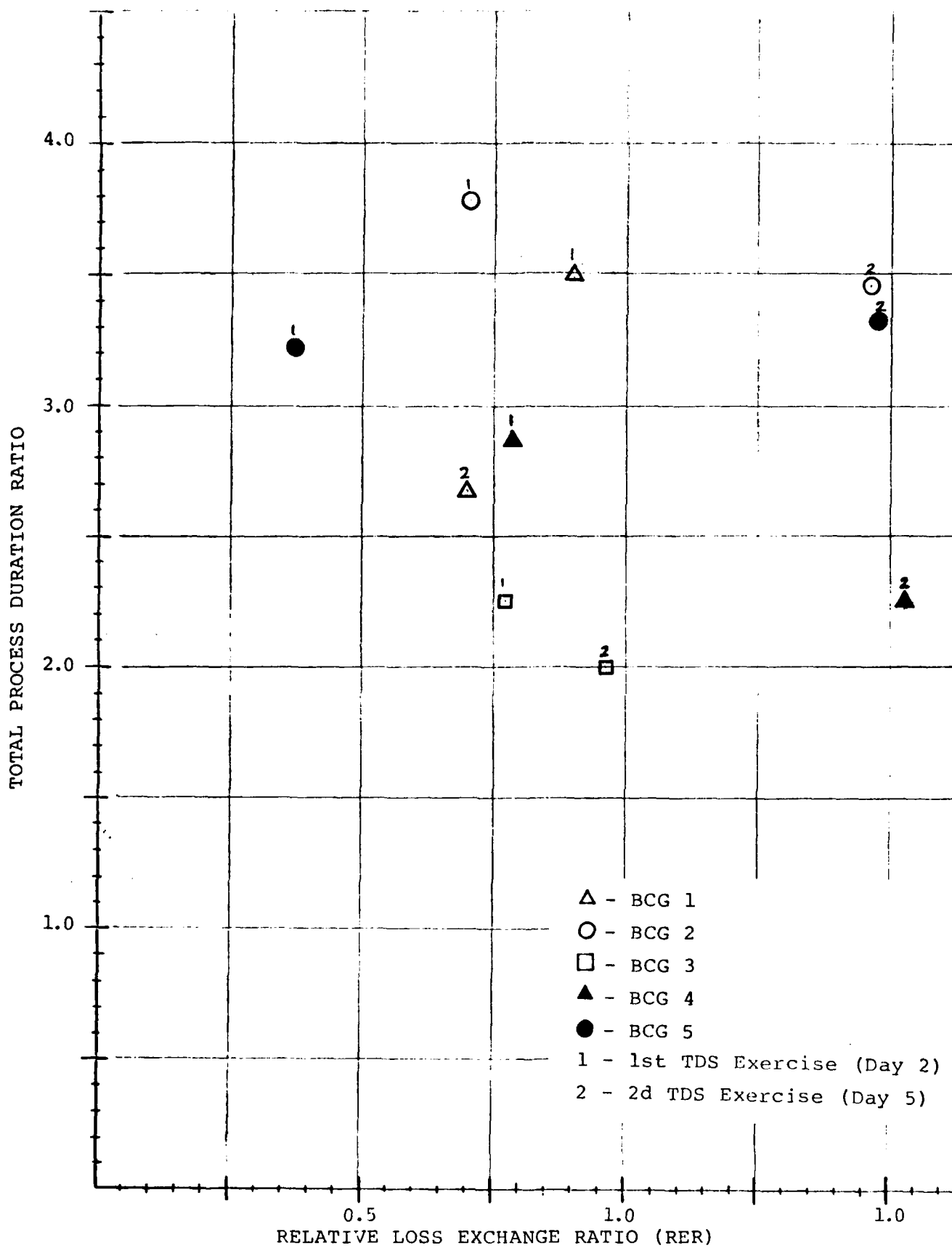


Figure 3-5. PROCESSES VERSUS BATTLE OUTCOME

correlation.

The contribution of the selected processes to total process performance is reflected in Table 3-4, and the principal observation derived from the information displayed in the table is that about half of the process time (47%) is spent on handling information (seeking, transmitting, and receiving), with a large portion of the balance being expended on staff coordination.

As with the data transfer duration ratio, analysis of Figure 3-5 reveals that for four of the five battalion command groups duration ratios for total processes decreased between the first and fourth TDS exercises, and for the fifth command group there was only a slight increase. This was to be expected since total processes are directly related to total data transfers. This decrease is attributed basically to improved efficiency after four days of exercise play (see paragraph 3.3.3.1 for additional rationale).

The staff process of receiving information shows a relatively uniform performance of this function over all exercises (Figure 3-6). This is again an indication of controller influence on exercise play since all information for the play of the battle simulation emanates from controller personnel. Duration ratios vary minimally depending on the time necessary to input information to each command group for the play of the exercise.

Table 3-4. PROCESS DURATION RATIOS

PROCESSES	DURATION RATIO	PERCENT OF TOTAL PROCESSES
Coordinating	1.05	36
Transmitting information	0.51	17
Seeking information	0.45	15
Receiving information	0.43	15
Assessing the situation	0.31	11
Other processes	0.18	6
Total processes	2.93	100

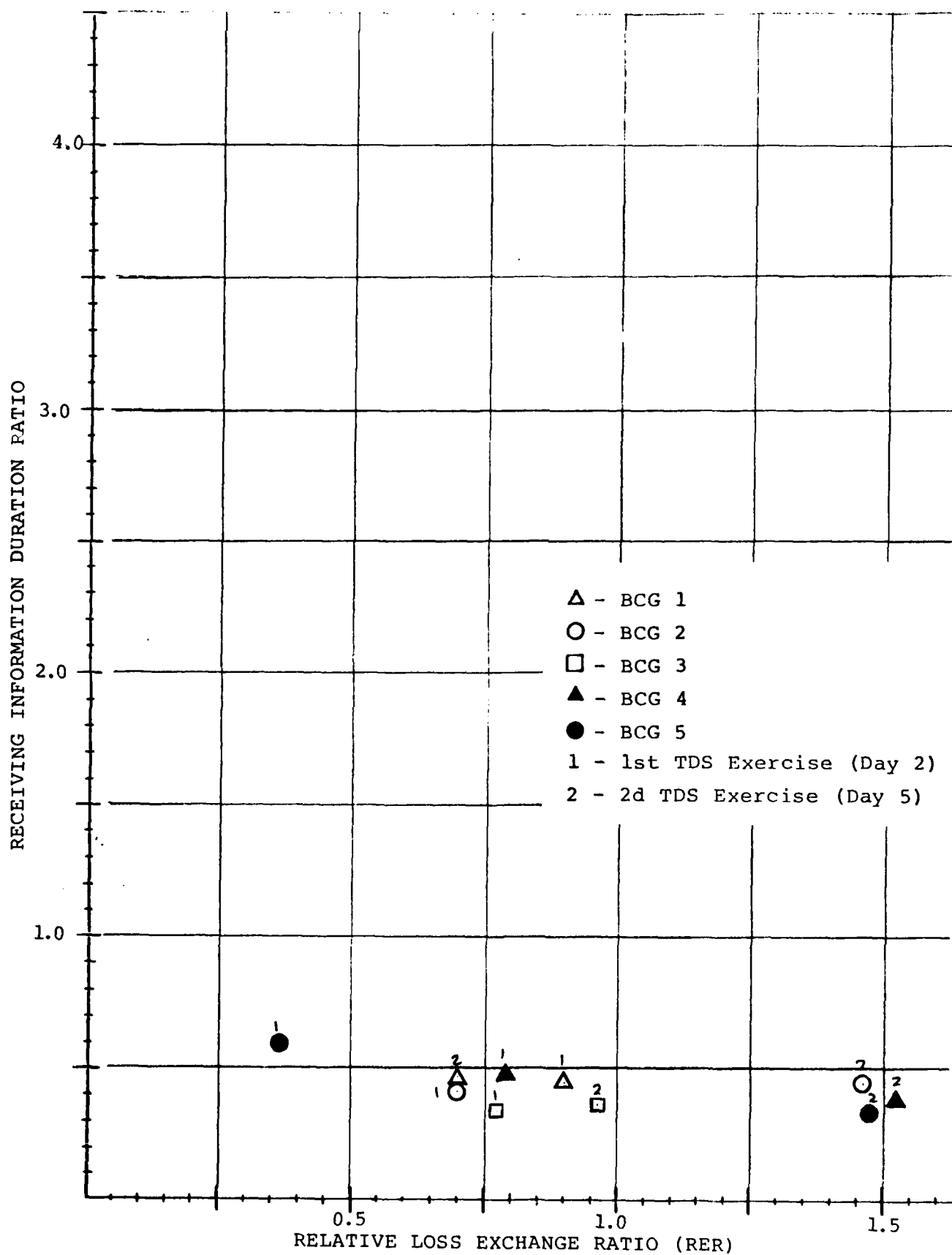


Figure 3-6. RECEIVING INFORMATION VERSUS BATTLE OUTCOME

With the exception of one command group the process of assessing the situation (Figure 3-7) fits tightly around the mean duration ratio. This was not expected because of variations in staff composition and qualifications. It was a surprise also because of the very highly judgmental classification of the activity by the military consultants, especially in the light of no observable data transfers to support quantification of the activity.

3.3.3.4 Subjective Analysis Results

The subjective analysis of battalion command group behavior during the TDS exercises (see paragraph 2.7 for methodology) yielded some interesting results. For each battalion command group, subjective ratings for selected performance measures as well as ratings for overall performance were awarded independently by the CATTS Chief Controller and by the SAI consultant who classified the behavior of the specific command group. These ratings were for overall performance over the set of exercises conducted by each command group. The ratings for participating command groups are shown in Table 3-5 and show surprising consistency.

SAI consultant ratings for each qualitative measure and for the battalion command group performance were then correlated with battle outcome for the final simulation

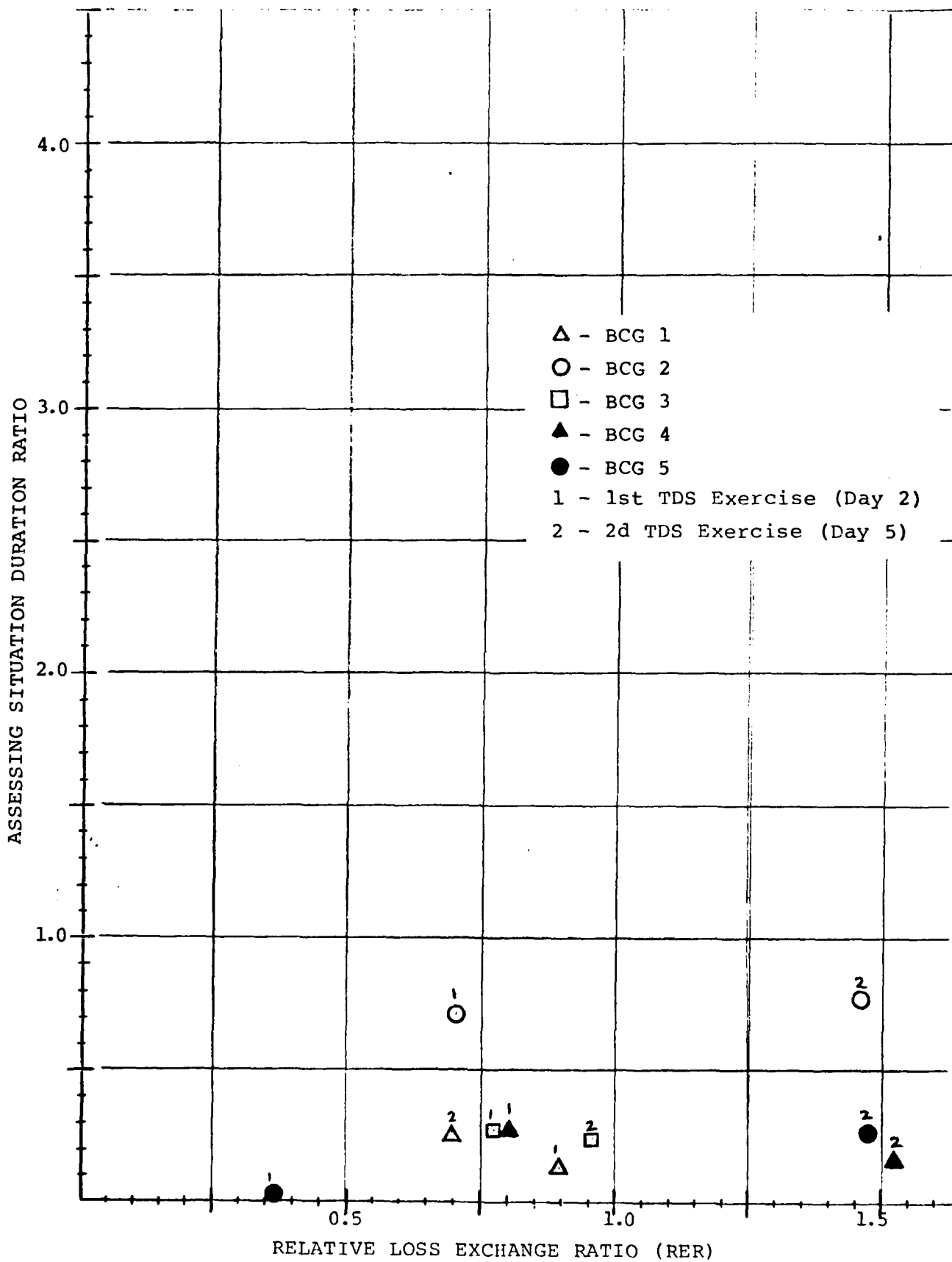


Figure 3-7. ASSESSING SITUATION VERSUS BATTLE OUTCOME

Table 3-5. COMPARATIVE SUBJECTIVE EVALUATIONS

SUBJECTIVE MEASURES	SUBJECTIVE EVALUATIONS									
	BCG 1		BCG 2		BCG 3		BCG 4		BCG 5	
	CC	SC	CC	SC	CC	SC	CC	SC	CC	SC
COMPETENCE	4	4	5	6	4	3	6	7	5	6
RELIABILITY	4	4	6	5	3	3	7	7	4	5
FUNCTIONAL INTEGRITY	5	4	5	5	4	5	6	7	5.5	6
FLEXIBILITY	5	4	6	6	5	4	6+	8	5	4
PROFESSIONAL QUALITY	5	3	6	5	3	5	7-	8	6.5	7
PERSONAL DEMEANOR	4	4	4	6	5	5	6	8	5	5
TEAM AWARENESS	5	3	4	4	4	5	6+	8	4	5
OVERALL RATING	5-	4	5	5	4	4	6.5	8	5.5	5

BCG - Battalion Command Group
 CC - Chief Controller
 SC - SAI Consultant

exercise of each four-exercise set. Because of the small sample size (n), degrees of freedom were adjusted using the formula $n-1$ inherent to the Pearson Product Moment Correlation (Games and Klare, 1967). As can be seen in Table 3-6, a high degree of correlation exists. The results of these correlations, although by no means conclusive, suggest that qualitative as well as quantitative measures of command group behavior should be explored more extensively and should possibly be included in the final methodology.

3.4 Exercise Data

Video and audio tape recordings were made of the ten Training Development Study (TDS) exercises, and those recordings are on file at the SAI facility in Leavenworth, Kansas. The recordings are necessary for third contract year efforts and will be retained at the SAI facility until completion of the current contract. These tape recordings will be delivered to the COTR at contract completion.

Interpretations of the video and audio tape recordings were prepared by the military consultants, and the resulting data were stored on computer disk at the SAI facility. Outputs for SAI analysis were generated from the exercise data, and samples of these outputs are displayed in Appendix F. Complete copies of the outputs will be delivered to the COTR under separate cover to be used in support of the ARI Training Development Study.

Table 3-6. CORRELATIONS OF QUALITATIVE MEASURES

QUALITATIVE MEASURE	BATTLE OUTCOME
COMPETENCE	.8732 p = .027
RELIABILITY	.7461 p = .074
FUNCTIONAL INTEGRITY	.8091 p = .049
FLEXIBILITY	.6289 p = .128
PROFESSIONAL QUALITY	.8425 p = .036
PERSONAL DEMEANOR	.7363 p = .078
TEAM AWARENESS	.6139 p = .135
OVERALL BATTALION COMMAND GROUP	.7938 p = .054

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations presented in this section are based upon contract performance through the second contract year. They are based upon the development and application of the initial methodology, the instrumentation of the CATTS facility for the capture of behavioral information, and data extraction and analysis. Early consideration of the recommendations would facilitate future evaluation of battalion command group behavior.

4.1 CONCLUSIONS

The conclusions presented below evolve from second contract year performance; however, they consider appropriate first contract year efforts and results. The conclusions are based only upon observation and analysis of battalion command group participation in CATTS exercises at Fort Leavenworth, Kansas.

- o There are no acceptable correlations between command group behavior and

command group effectiveness as determined by the application of the initial methodology.

- o The initial methodology and the environment in which it is applied require refinement if useful quantitative results are to be achieved through its application.
- o Acceptable and more meaningful measures of command group effectiveness as well as combat effectiveness (battle outcome) are necessary to a successful behavior analysis methodology.
- o High reliability of data classification is essential to meaningful interpretation of command group behavior.
- o Qualitative techniques of evaluating command group behavior should be included in future development of methodologies, and criteria for the integration of quantitative and qualitative techniques should be established.
- o Command and control behavioral research requires careful planning, structuring, and control to produce useful results.
- o CATTS appears to be a highly

valuable training laboratory but is of questionable value as a behavioral research laboratory.

- o Instrumentation systems for future behavioral research laboratories should be designed and implemented in an integrated fashion, taking full advantage of state-of-the-art techniques and equipment; ease of automatically capturing and recording useful data should be considered as a means of conserving time and other resources.
- o Battalion command group participants in behavioral research should meet standards of training, experience, and competence and should conform to standard rules for participation.
- o Simulations to be used in behavioral research should be selected and/or developed to achieve research objectives, and sensitivity tests should be conducted to ensure valid and useful relationships between performance and effectiveness.
- o An electronic computational system is highly useful in command and control behavioral research.

4.2

RECOMMENDATIONS

The following recommendations are based upon the conclusions above and are advanced to enhance third contract year performance as well as to influence future command and control behavioral research. It is recommended that

- o The initial methodology be refined within the constraints of the present laboratory.
- o A qualitative methodology(ies) for evaluating command group behavior be developed and that criteria and techniques for integrating the quantitative and qualitative methodologies be established.
- o ARI consider a more advanced laboratory for planning, structuring, and conducting command and control behavioral research.

SECTION 5

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APPENDIX A
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APPENDIX B
ACRONYM GLOSSARY

ADA	- air defense artillery
AH	- attack helicopter
ALO	- air liaison officer
AM	- amplitude modulation
ANOVA	- analysis of variance
APC	- armored personnel carrier
ARI	- Army Research Institute
ARMD	- armored
ARNG	- United States Army National Guard
ARTEP	- army training and evaluation program
ARTY	- artillery
AVN	- aviation
BCG	- battalion command group
BDE	- brigade
BN	- battalion
C2	- command and control
CAC	- Combined Arms Center
CACDA	- US Army Combined Arms Combat Developments Activity
CAS	- close air support
CATRADA	- US Army Combined Arms Training Development Activity
CATTS	- Combined Arms Tactical Training Simulator
CAV	- cavalry
CBT	- combat
CEOI	- communication electronics operating instructions
CHAP	- chapparal
CML	- chemical
CO	- commanding officer
COC	- character oriented communication
COTR	- contracting officer's technical representative
CSC	- combat support company
DIO	- digital input/output
DISCOM	- division support command
DIV	- division
DMA	- Defense Mapping Agency
DPFO	- data processing field office
DS	- direct support
ENGR	- engineer

FAC	- forward air controller
FDC	- fire direction center
FIST	- fire support team
FM	- field manual
FM	- frequency modulation
FORSCOM	- US Army Forces Command
FSCC	- fire support coordination center
FSO	- fire support officer
GS	- general support
HHC	- headquarters and headquarters company
IMI	- individual/multi-individual
INF	- infantry
IR	- infrared
LER	- loss exchange ratio
MACE	- (battalion level battle simulation)
MECH	- mechanized
MI	- military intelligence
MOE	- measure of effectiveness
MP	- military police
NBC	- nuclear, biological, chemical
NCO	- non-commissioned officer
NTC	- National Training Center
RATT	- radio teletype
REFORGER	- Redeployment of Forces to Germany
RER	- relative loss exchange ratio
RTO	- radio telephone operator
S1	- personnel staff officer
S2	- intelligence staff officer
S3	- operations and training staff officer
S4	- logistics staff officer
SAI	- Science Applications, Inc.
SIG	- signal
SLAR	- side looking airborne radar
SMFRD	- surviving maneuver force ratio differential
SP	- self-propelled
SQDN	- squadron
SWBD	- switchboard
TACP	- tactical air control party
TCS	- tactical computer system
TCT	- tactical computer terminal
TDS	- Training Development Study
TK	- tank
TOC	- tactical operations
TRADOC	- US Army Training and Doctrine Command
UHF	- ultra high frequency
USAF	- United States Air Force
USAR	- United States Army Reserve
VUL	- vulcan

APPENDIX C

COMBINED ARMS TACTICAL TRAINING SIMULATOR (CATTS)

The Army Research Institute proposed, and SAI accepted, the use of the Combined Arms Tactical Training Simulator (CATTS) to be the vehicle by which data for battalion command group behavior analysis were to be generated. CATTS is acknowledged to provide an environment requiring the immediacy of real time decision processes necessary to combat a trained, experienced, and thinking enemy.

CATTS is a computer-driven battle simulation which trains commanders and staffs of mechanized, light infantry, and armor battalions, as well as armored cavalry squadrons, in the control and coordination of combined arms operations. It simulates the actions of units in combat and calculates intervisibility, weapon-to-target ranges, and the effects of all weapons employed. It maintains the status of personnel, equipment, ammunition, and fuel for friendly and enemy forces. A CATTS exercise is conducted in a real-time, free play mode in a variety of terrain areas.

The CATTS system is designed to enhance the professional knowledge of a battalion commander and his staff on the necessary actions, decisions, and coordination that must occur in an efficiently operated battalion tactical operations center during combat operations. CATTS provides a realistic approximation of a battlefield environment. The participating battalion command group has the communication equipment normally found in a maneuver battalion. The tactical operations center is configured to simulate a combat environment. Appropriate background noise (engines and generators), battle sounds, and electronic warfare jamming are generated throughout the exercise. Because CATTS is a free play exercise, the only constraints are the assets available to the battalion commander and the actions of the enemy force, normally a motorized rifle regiment. The battalion commander may employ his assets in any manner he deems appropriate within the prescribed tactical situation. The battle outcome is determined by the skill of the participants rather than through the use of a canned scenario.

CATTS is the premier command group trainer for US Army Forces Command (FORSCOM) Active Army and Reserve Component battalion staffs. It was developed at the US Army Infantry School, Fort Benning, Georgia; however, since early 1976 it has been permanently located at the Combined Arms Center, Fort Leavenworth, Kansas.

This appendix provides a description of CATTS which will substantiate its selection as the laboratory for the collection, analysis, and evaluation of battalion command group behavior; discusses CATTS as a research laboratory; describes participating military organizations; and outlines the conduct of the simulation exercises.

1 SIMULATOR ARCHITECTURE

CATTS is a real time command group trainer that interactively maneuvers and fights opposing forces in simulated combat operations. Units are modeled down to platoon level and include individual and crew-served weapons and equipment. A computer determines and calculates movement rates and line-of-sight using three-dimension digitized terrain; determines engagements between opposing forces; and assesses casualties and damage from direct fire, indirect fire, and air-to-ground and ground-to-air engagements. Essentially, CATTS is an automated training aid which approximates the decision-making experience which otherwise can be obtained only through actual participation in combat operations.

1.1 Computer System

The technical challenge the CATTS system attempts to meet is to give the controller an aid to calculate battle outcomes rapidly enough and realistically enough for training needs without constraining the freedom of action of the battalion command group. This is accomplished through the use of a large-scale computer system on which the battle is simulated by a mathematical model, which calculates the battle outcomes, and a set of sophisticated interactive graphics programs and display devices which allow two-way communication between the controllers and the mathematical model.

The computer chosen for CATTS is the Xerox Sigma 9 Model 3 with 128K of 32 bit words in core storage. It is configured with three real-time clocks which drive the command and control, graphic display, and map software, respectively. The peripherals include a console teletype, a second teletype which serves as a simulated radio teletype (RATT), a card reader, a high-speed line printer, two magnetic tape drives, two high speed line printers, two magnetic tape drives, two high-speed disk drives providing almost 90 megabytes of on-line storage, a character oriented communications (COC) device, and a digital input/output (DIO) device.

1.2 Digitized Terrain

A digitized terrain data base is the link between the players' situation maps and the computer. Three geographical areas (Sinai; Fulda, Germany; and National Training Center, Fort Irwin, CA) are currently in use for simulation exercise play; however, any geographical area for which digitized terrain is available could be used. An area 30km X 110km is modeled with a fidelity of 25 meters, which provides 5.2 million points. For each point, elevation, slope, vegetation type, soil type, hydrography, and man-made features are stored.

1.3 Graphic Display

A graphic system overlays unit symbology and other military graphics on a terrain map. As a camera is moved, panned, and zoomed, the graphics are redrawn to scale on the area viewed. Coupled with the computer system, this capability allows exercise controller personnel to view the battle graphically as it progresses.

1.4 Mathematical Model

The CATTS mathematical model is a large, detailed, complex digital computer simulation of the tactical battlefield environment. It is a time-step model, with timesteps of one minute (except for air units, which have

quarter-minute steps). It calculates, for each minute of battle, the detections, engagements, fires, casualties, movements, and environmental effects for up to 99 units. The baseline scenarios have units which vary in strength from a squad to a battalion, with the normal level of platoon for friendly units and company for enemy units.

The computer simulation is actually a closed loop system in which the mathematical model calculates outcomes and displays those outcomes to the controllers as alphanumeric messages on display devices, and also as full color military graphic symbology overlaying a full color military map on color television monitors. The appropriate role-playing controllers relay information to the battalion command group over the communications system. The command group members react and relay their orders and requests for support back to the appropriate controllers over the communications system. The controllers use graphic tablets and the color displays (plus a complex set of command and control computer programs) to enter the full spectrum of appropriate military commands to the mathematical model, which updates the necessary model variables to carry out the commands, thus changing all future battle outcome calculations. This closed loop, interactive system frees the controllers to dedicate their efforts to role playing and to the training process, rather than to the calculation of casualties, movements, and other battle results.

The mathematical model is divided into a number of modules, each with a specific function. A brief overview of these modules is provided in the following subparagraphs.

1.4.1 Executive and Simulation Control Module

The Executive and Simulation Control Module has the responsibility of overseeing mathematical model execution. It moves the correct overlay segments to/from core when required, directs the execution of the various other modules, handles the interface between programs, saves the data necessary for replay and restart on disk files, and performs most of the functions of simulation control.

1.4.2 Command and Control Module

The Command and Control Module provides interface between the exercise interactor (controller) and the computer. The commands of the players are input by the interactor using suitable menus for such activities as movement, fire control and resupply.

The Command and Control Module performs the necessary data base updates for both the interactive and the table-driven command and control in the mathematical model. The table-driven portion uses a tabular set of input decision rules which determine changes in unit status if the conditions specified in the table are met.

1.4.3 Environmental Module

The Environmental Module has two purposes. One is to calculate the existence of lines of sight between eligible ground units, considering terrain relief and vegetation, climatology, time of day, and battlefield obscuration (e.g., smoke, fog). This calculation is accomplished by a complex model using a large terrain data base developed from Defense Mapping Agency (DMA) provided data.

The second purpose of the Environmental Module is to update the global weather conditions, which include:

- o Temperature
- o Relative humidity
- o Weather class (selected from 11)
- o Meteorological visibility
- o Ambient light level
- o Wind velocity
- o Wind direction

1.4.4 Target Acquisition Module

The Target Acquisition Module determines the occurrence of detections between eligible pairs of units and generates alphanumeric alert messages when detections occur. Many environmental and tactical considerations and a wide range of sensor types have been modeled.

1.4.5 Ground Fire Module

The Ground Fire Module is a complex, detailed module which allocates and controls all ground weapons modeled in CATTS. Considering weapons systems available to a unit, range to the target, operational state, and extent of suppression, the module calculates engagement results. Rates of fire, weapon effects, probability of hit, and probability of kill influence engagement outcome.

1.4.6 Ground Movement Module

The Ground Movement Module controls and directs the movement of all ground units in the area of operations. At each mathematical model timestep, each unit is examined to determine whether it should start or stop moving. For moving units, a movement rate is calculated based on tactical considerations, existing and new engagements, suppressions, and environmental factors. Units may move singly or as part of an operational grouping. The disruptive effects of terrain and obstacles to movement are also modeled.

1.4.7 Air Movement and Fire Module

Air assets available to opposing forces include both combat and cargo aircraft (fixed wing as well as rotary wing). Based upon aircraft availability, capabilities, and ordnance, this module flies directed air missions and performs damage

assessment. Reconnaissance missions are also flown by this module, and results appropriate to the observation system (e.g., SLAR, IR) are reported. Finally, air unit casualties from air defense systems are also calculated by this module.

The Air Movement and Fire Module updates location, direction, speed, and altitude of each air unit according to individual, input flight plans. This occurs at intervals of one quarter-minute or less. For each quarter-minute air/ground interactions are calculated, including detections, firing, air weapons delivery, and casualty assessment.

1.4.8 Engagements Module

The purpose for the Engagements Module is to cause ground units in the model to respond in a tactically realistic way to enemy fire and/or proximity. It determines when units will fire direct fire weapons, when they will form engagements, and when they will break them off.

1.4.9 Logistics Module

This module calculates and reports unit status by time step. Calculations are made based upon personnel and materiel casualties suffered and ordnance and fuel expended. Critical status of personnel and materiel is reported as it occurs. A cumulative status report may be requested at any time, and end-of-battle status is reported for each exercise.

1.4.10 Other Modules

A variety of input/output, ancillary, and miscellaneous modules exist to initialize the system, drive line printers, generate messages and reports, and provide other system services.

2 CATTS AS A RESEARCH LABORATORY

A primary objective of SAI under its current contract is to conduct research into command group behavior; however, it must be recognized that the laboratory for the conduct of this research is a training laboratory not a research laboratory. The CATTS facility and all of its operating personnel are elements of an Army agency subordinate to the US Army Training and Doctrine Command (USA TRADOC), and the primary mission of the facility is to train battalion command groups of the Active Army and Army Reserve Components. ARI and its contractor, SAI, are guests in the CATTS environment, and their research activities therein must in no way detract from the primary mission of the facility. Through the excellent cooperation of the Combined Arms Center at Fort Leavenworth, it has been possible for SAI to instrument activities and to collect large amounts of data for behavior analysis. It has not been possible, however, to conduct the optimum command group behavior research using the CATTS laboratory; nevertheless, highly useful results have been obtained from the CATTS laboratory towards identification,

quantification, and analyses of the impact of group behaviors in military command and control.

In its totality, the laboratory for SAI's research into command group behavior consists of the exercise simulator (CATTS); the physical facility in which the simulation exercises are conducted; the instrumentation of the facility to not only control the exercises but also to extract behavior data; the military cadre which exercises the simulator and controls the exercises; and finally, the battalion command groups which participate in the exercises and which are the subject of behavior analysis. In the balance of this paragraph, however, only the physical facility will be addressed; all other elements of the laboratory are addressed in separate subparagraphs of this appendix or, in the case of CATTS instrumentation, in Appendix D.

The main CATTS facility is one of several tenants in Rucker Hall, Fort Leavenworth, Kansas. The physical layout and spatial relationships of the CATTS facility are displayed in Figure C-1 and are discussed below.

2.1 Computer Room

The computer room of the CATTS facility houses the Xerox Sigma-9 computer system which provides computational support for the simulation exercises. In addition to the computational support, the computer system drives various graphic displays used for control of the exercise. The

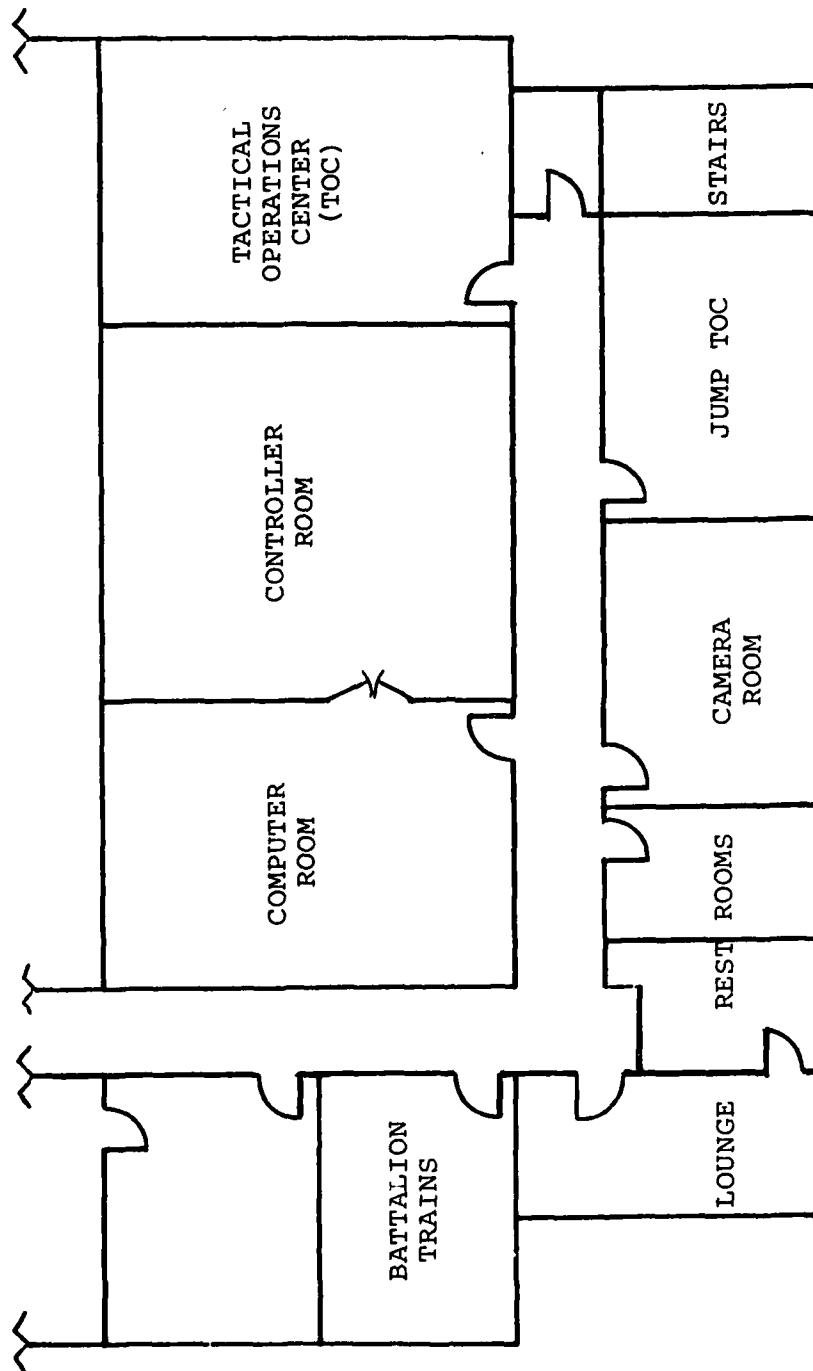


Figure C-1. COMBINED ARMS TACTICAL TRAINING SIMULATOR FACILITY

Sigma-9 consists of the system and the peripherals listed in paragraph 1.1 above.

2.2 Controller Room

The controller room is the main work area for all of the controllers and is the nerve center for the exercise of CATTS. Except for occasional face-to-face meetings between players and controllers who are role playing, all controller activities are conducted in this room.

The controller room is configured as shown in Figure C-2. Three V-shaped multi-use consoles provide computer input/output for game play as well as communications between the controllers and the players. As can be seen, the three consoles are organized to embrace the functional areas as follows:

Console 1 - Indirect fire support, air reconnaissance and close air support, and attack helicopters.

Console 2 - Opposing (enemy or threat) forces plus brigade personnel and logistics activities.

Console 3 - Maneuver units of the battalion task organization.

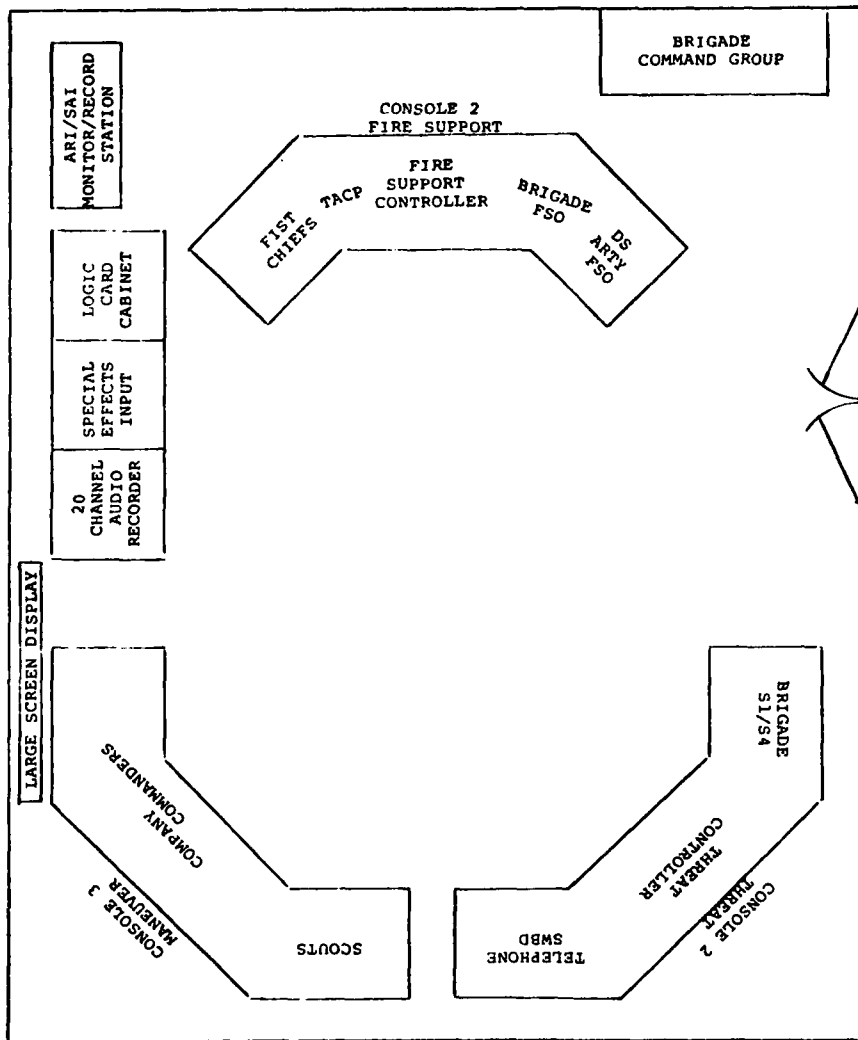


Figure C-2. CATTS CONTROLLER ROOM

The controllers comprising the brigade command group and adjacent units occupy an independent station, and ARI/SAI staff a monitoring and recording station in the controller room. A 20-channel audio recorder records all radio, telephone, and live conversations in the player areas. A capability of providing background/battle noises in the player areas is exercised from the control room at selected times in the battle scenario. Finally, a closed circuit television monitoring system allows full time observation and recording of player activities. During an exercise, the controller room, computer room, and camera room are off limits to players.

2.3 Camera Room

Graphic displays for exercise play and control are generated in the camera room using video cameras and map displays. Unit symbology and other military graphics are overlaid on video monitors by means of a random access memory digitized terrain device driven off of the supporting computer system. Automated graphic displays are not generally available to battalion command group players.

The camera room contains three color television camera systems, one supporting each controller console, each of which is comprised of:

- o A large full-color military map mounted on a cylindrical map board.

- o A color television camera with zoom lens, mounted on a pan/tilt table.
- o A zoom motor and a zoom encoder.
- o A pan motor and a pan encoder.
- o A tilt motor and a tilt encoder.

2.4 Tactical Operations Center

The primary location for exercise play is the battalion tactical operations center (TOC) which represents the battalion command post. The TOC is physically configured and constructed to simulate a field command post, to include canvas tent and camouflage net installation. It is furnished with folding field tables and chairs as well as with other standard Army command post paraphernalia (maps, overlays, grease pencils, etc.). The layout of the command post is as shown in Figure C-3.

The TOC, as well as the battalion trains and forward command post (Jump TOC), are considered to be tactical areas during an exercise. No visitors are admitted to these areas without the approval of the chief controller. Controllers have limited access to these player areas and enter them only when necessary for effective exercise control. Movement from one simulated tactical location to another must consider appropriate travel time. All player areas are connected to the CATTS sound system in order that background/battle noises may be introduced when appropriate.

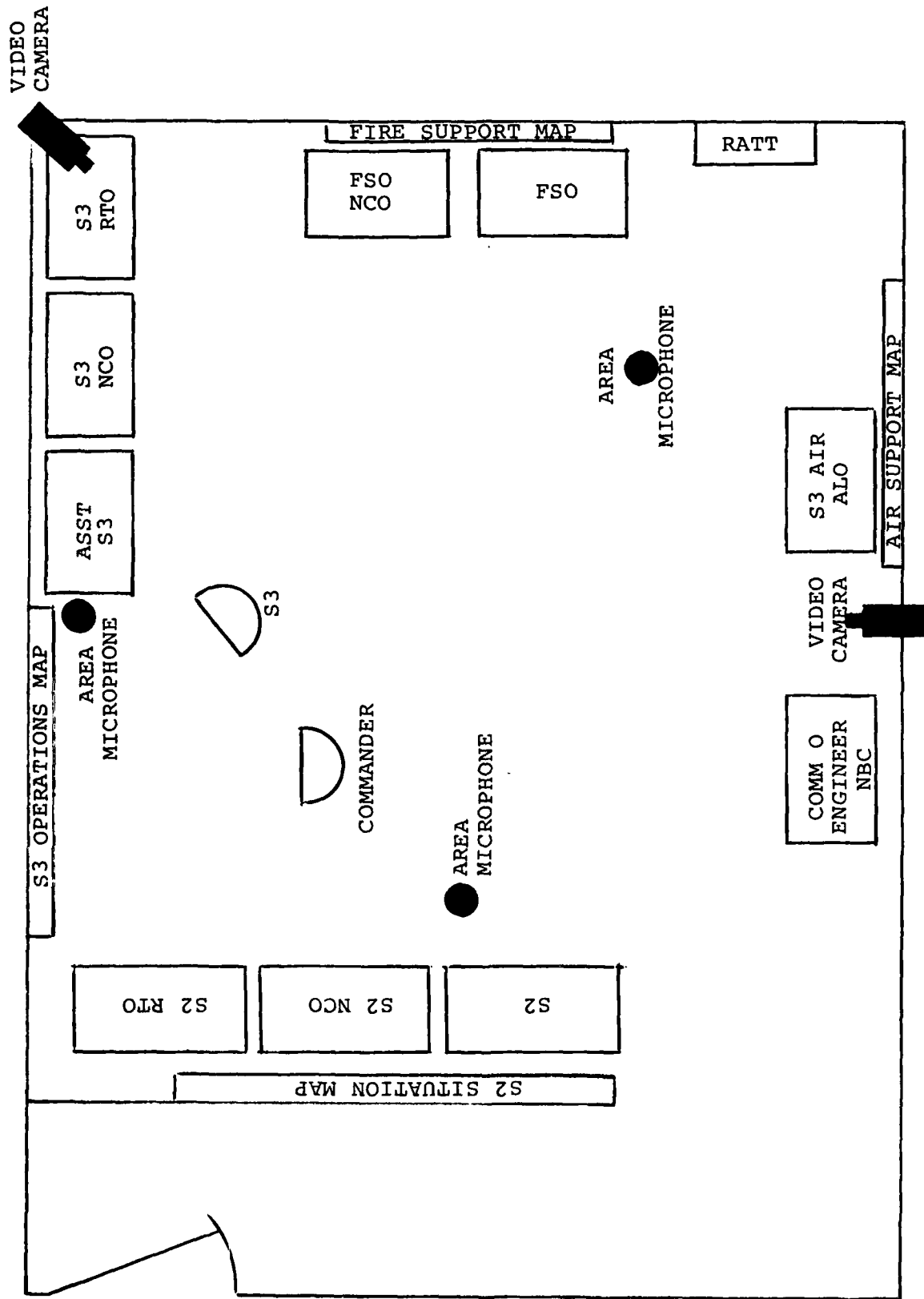


Figure C-3. TACTICAL OPERATIONS CENTER

Periodic displacement of the TOC must be simulated in accordance with the tactical situation. Initial and subsequent positions must be reported by players to the controllers so that the locations may be entered in the simulation.

Communications within and among command and control locations are as discussed in paragraph 2.7 below.

2.5 Forward Command Post

The forward command post, commonly referred to as the jump TOC, is the facility which offers the commander and selected members of his staff an opportunity to gain experience in the operation from a command location separated from the TOC. In actual combat situations, such a capability permits the commander to observe the status of the battle first hand and to coordinate more effectively with his subordinate commanders. The term jump TOC is derived from the fact that the forward command post is placed in operation during the time that the TOC may be displacing. A diagram of the forward command post is shown in Figure C-4.

The forward command post consists of two mock-up vehicles, an M-577 command carrier and a 1/4 ton truck. Communications available to this location include only radio, as explained in paragraph 2.7 below.

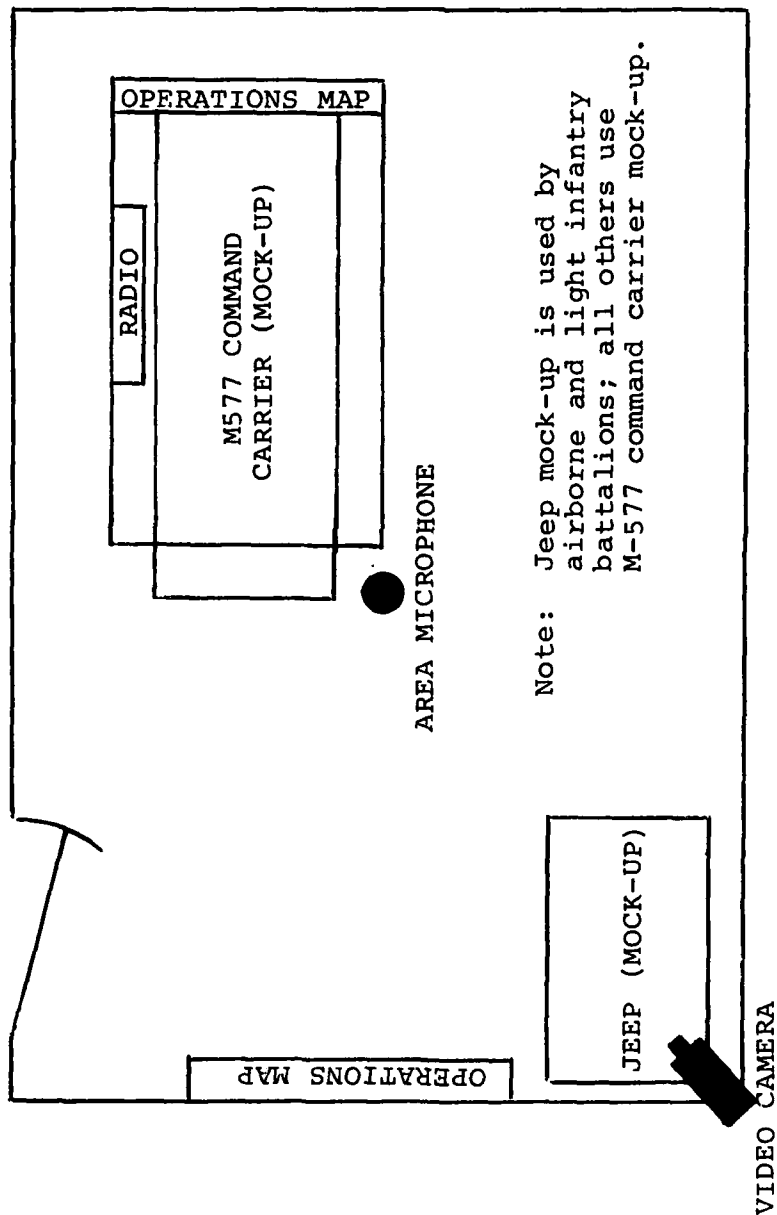


Figure C-4. FORWARD COMMAND POST (JUMP TOC)

2.6 Battalion Trains

The administrative and logistics support of the battalion is planned and controlled from the battalion combat trains, the designation of a facility which would be located rearward from the TOC in actual combat operations. The rearward location of the battalion trains facilitates combat service support of battalion operations.

The battalion trains, as is the TOC, is simulated as being under canvas and properly camouflaged. Communications are provided to the battalion trains as discussed in paragraph 2.7 below. A diagram of the battalion trains facility is shown in Figure C-5.

2.7 Communications System

All player areas are equipped with adequate radios and field telephones to provide both secure and non-secure communications between the various locations of the battalion command group. These communications are representative of the equipments and capabilities normally available at battalion level.

The frequency modulated (FM) radio system consists of tactical radios which have been gutted and hardwired to operated realistically in the CATTS communications system. The FM system is limited to 16 frequencies, and each radio has a secure/non-secure capability.

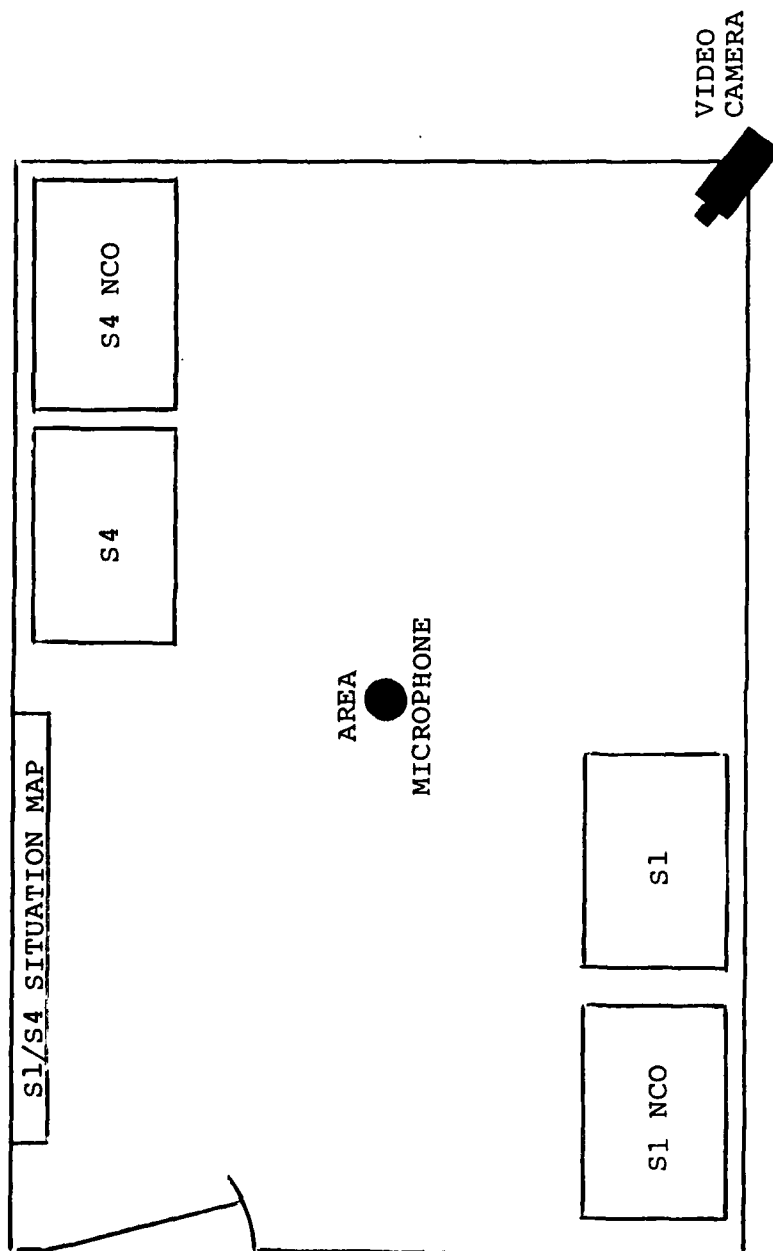


Figure C-5. BATTALION TRAINS

The exercise players have one radio with an amplitude modulated (AM) capability, and it is part of the radio teletype (RATT) system. The radio may be used for voice communications but not simultaneously with RATT operations. The AM radio is hardwired for operation on one pre-set frequency.

The players may send and receive secure messages over the RATT. Although not a standard RATT, the exercise system provides the same capability. The brigade controllers maintain a file of canned messages for transmission over the RATT system.

The CATTS system does not currently possess an ultra high frequency (UHF) capability; therefore, USAF controllers and players use one of the FM channels to simulate their normal complement of UHF radios.

To simulate telephone communications, the exercise players have five field telephones in the player areas that interface with the communications system through a simulated switchboard in the control room. Players may communicate over land telephone lines with any unit, provided the tactical situation and equipment normally available to the unit permit. The controller switchboard operator is responsible for routing and monitoring each unit's telephone capability.

Players and controllers send and receive messages to and from higher and subordinate units via a simulated message center. Adequate travel time is taken into consideration for the distribution of these messages.

Standard communication/electronics operating instructions (CEOI), operations codes, and encryption devices are issued to the command group for exercise play.

3 PARTICIPATING MILITARY ORGANIZATIONS

Battalion command groups are selected for participation in CATTS exercises from units of the Active Army, from Army Reserve components (US Army Reserve and Army National Guard), and from ad hoc Army organizations which have a specific, approved purpose for use of the CATTS system. Command groups participating in the exercises during the period April 1981 - March 1983 have included the following units by source:

Active Army	34
Reserve Components (ARNG only)	5
Human Engineering Laboratory,	1
Aberdeen Proving Ground	

Of the total units shown, only five Active Army battalion command groups were the subject of behavior analysis during the second contract year.

Battalion command groups which have participated in CATTS exercises have represented a variety of Army battalion types as follows:

Mechanized (infantry) battalions

Light infantry (airborne and airmobile)
battalions

Armor battalions

Armored cavalry squadrons

Battalions which participate in the CATTS exercises are simulated to be organized into combined arms battalion task forces. A battalion task force is a combination of tank and infantry companies and other units grouped under the command of the headquarters of an infantry or armor battalion or of an armored cavalry squadron. The task force commander and his staff must fully understand the capabilities and limitations of each element of the force as well as the force as a whole. He must organize the force to maximize the potential of the forces assigned to him. Finally, he must make the organization work by aggressive, competent, and uncomplicated control and leadership. The CATTS facility provides an excellent tool for training the battalion command group to this end as well as provides a laboratory for observation of command group behavior during the training and simulated combat.

The Army has recommended the best battalion command group composition for participation in the CATTS exercise to be the following:

Players

Battalion Commander
S1 or S1 NCO (one)
S2
S2 NCO
S2 RTO (optional)
S3
S3 Air
S3 NCO
S3 RTO
S4 OR S4 NCO (one)
S1 or S4 RTO (one)
Fire Support Officer
Fire Support NCO
Air Liaison Officer (USAF)
Engineer Platoon Leader
Communications Officer
RATT Operator (optional)

Controllers

Company Commanders (4)
FIST Chief (2)
Scout Platoon Leader
Support Platoon Leader
Forward Air Controller (USAF)

In general, participating battalion command groups have conformed to the guidelines; however, in a number of cases the group will participate with either a truncated or an extended staff organization.

The players of the battalion command group as constituted above are the subjects of behavior analysis under the SAI contract.

4 SIMULATION EXERCISES

The battalion command groups exhibit their experience, capabilities, and competence as command groups by participating in the CATTS simulation exercises. It is through the play of these exercises that SAI is able to extract data for behavior analysis; therefore, it is important that the simulation exercise play be fully understood by the investigators (SAI) as well as by the Army personnel who will review and benefit by the investigation and analysis.

Active Army and Reserve Component battalion commands participate in CATTS exercises of different durations. Simulation exercises for Active Army units are typically conducted over a three day period (Tuesday through Thursday). The participation by Army National Guard (ARNG) units is normally over a two day weekend in order to conform to their active-duty-for-training periods. The exercises conducted for ARNG are, therefore, truncated versions of the Active Army exercises. It is more appropriate, then, to discuss those exercises conducted by Active Army units.

A unique departure from typical exercises was followed by battalion command groups which were studied during second contract year performance. Five Active Army battalion command groups each conducted four successive one-day CATTS exercises, and group behaviors from two exercises of each four exercise set (a total of 10 exercises) were the subject of SAI behavior analysis. This exercise format was necessary to accommodate concurrent studies being performed by the Army Research Institute.

4.1 Exercise Environment

The geographical areas for the conduct of the CATTS exercises are limited to the areas of the world for which digitized terrain representation is available from the Defense Mapping Agency. Weather and climatology information pertinent to the area is provided for the exercises.

From among a number of candidates, three geographical areas have been chosen. Each of the geographical areas offers the opportunity for a variety of military operations to be conducted. The three geographical areas are:

Sinai Peninsula of Egypt

Fulda Gap area of West Germany

National Training Center at Fort Irwin, CA

4.2 Simulated Military Operations

Scenarios for a variety of military operations are necessary to test the complete spectrum of battalion command group capabilities and versatility. Coupled with this observation is the acceptance of the fact that some units are better suited by organization and mission to participate in one type operation than in another; for example, an armored cavalry squadron is well suited to covering force, movement to contact, and reconnaissance operations while an armor battalion or an armor/mechanized infantry battalion task force is well suited to participate in face-to-face offensive and defensive confrontations with the enemy. For these and other reasons, the following menu of military operations is offered for units participating in the CATTS exercises.

Division Attack

Hasty Attack

Covering Force

Movement to Contact

Delay

Hasty Defense

Deliberate Defense

Scenarios combining military operations may also be offered as part of the menu; for example, movement to contact coupled with hasty attack.

4.3 Exercise Schedule

A three-day Active Army simulation will typically be scheduled as follows:

First Day

0730-Players arrive and are presented an administrative briefing.

0830-Warning order is issued to the battalion command group.

-Instruction on the use of the CEOI and the communication system is presented.

-Company commanders initiate controller training.

0900-Battalion commander and S3 report to brigade for situation update and for receipt of the brigade operation order.

-Brigade staff briefs battalion staff counterparts.

0930-Battalion command group initiates preparation of battalion operation order.

1500-Battalion command group briefs the operation order to the company commanders.

1630-Terminate first day activities.

Second Day

0730-Players arrive.

0830-Exercise initiated.

1500-Exercise terminated; feedback session conducted.

1630-Terminate second day activities.

Third Day

0730-Players arrive and receive intelligence update; receive brigade operation order for continuation of the exercise.

1000-Battalion command group completes plan for new operation; operation order issued to company commanders.

1100-Exercise initiated.

1430-Terminate simulation.

1445-Feedback session conducted.

1530-CATTS system explanation and demonstration.

1615-Activities terminated; unit departs.

4.4 Simulation Exercise Play

The heart of the CATTS training is the conduct, under simulated battle conditions, of the military operation. The battle (simulation) is joined by the issuance of the brigade operation order to the participating battalion commander. From that point on, the exercise is divided into two distinct activities; planning and operations.

4.4.1 Staff Planning

The receipt of the brigade operation order, coupled with the battalion commander's concept of operations and his guidance, projects the battalion command group into the planning phase of the exercise. The staff analyzes the mission, collects and assesses information, conducts intra-command group coordination, prepares staff estimates, and briefs the commander. The battalion commander orchestrates the planning activities, receives the staff estimates, prepares his commander's estimate of the situation, and makes his decision relative to the operation to accomplish the mission assigned by the brigade or task force commander. An operation order is prepared by the staff, approved by the commander, and issued to the company commanders for execution.

The planning activities of the battalion command group are recorded on video and audio tape for behavior analysis by SAI; however, command group behavior during the planning sessions was not analyzed during second contract year performance.

4.4.2 Mission Performance

Conforming to missions assigned in the battalion operation order, the simulated battalion exercise is initiated and is thereafter conducted in real time. The command group is challenged to perform substantially as they

would under actual combat conditions. As the battle unfolds, the staff is confronted with the tasks of collecting information and assessing the situation; with communicating and coordinating information and staff activities within the staff section, between staff sections, and with higher, adjacent, supporting, and subordinate units; with making staff estimates and advising the commander; with the decision-making process, including the implementation of any decisions made; and with supervising the prosecution of the battle by subordinate units.

The complete simulation exercise is recorded on video and audio tape for behavior analysis by SAI. The mission performance phase of the exercise provides the basis for second year analysis of command group behavior.

APPENDIX D

CATTS INSTRUMENTATION

CATTS exercises are carefully instrumented for two main purposes; one, for control of the exercise play, and two, for the purpose of collecting data for behavior analysis. Only the latter instrumentation will be discussed in this appendix since it is directly applicable to contract performance.

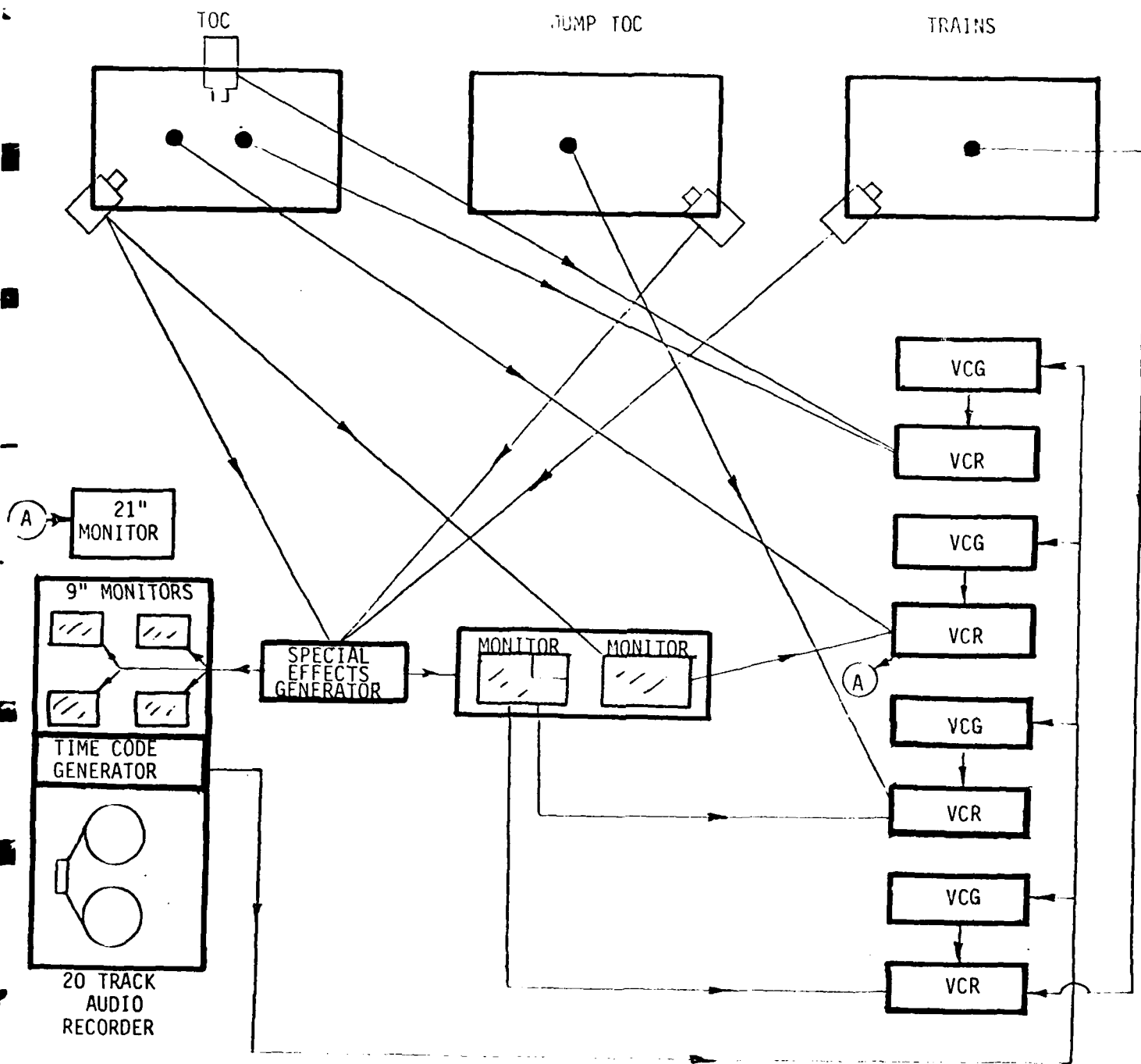
Under its contract, as amended, with the Army Research Institute, SAI was authorized to purchase for the account of the government items of equipment required for the performance of the contract. In responding to this requirement, SAI conducted a requirements analysis, reviewed state-of-the-art instrumentation components, prepared an instrumentation enhancement plan, and submitted the plan to the COTR. In keeping with the plan and within available resources, SAI purchased the planned items, integrated them into the existing system, and achieved a complete data instrumentation package. It is the enhanced CATTS instrumentation which is described in this appendix.

1 VIDEO INSTRUMENTATION SYSTEM

The principal system used by SAI for the collection of behavior data from CATTS exercises is the integrated video/audio system diagrammed in Figure D-1. From a combination of area microphones and video cameras in the TOC, jump TOC, and battalion trains, four video tapes each with an audio track are recorded. In the process of recording, a time code generator and a video character generator impose a time signal on each video tape. The time signal recorded is game time rather than real time. This time code is vital to the correlation of activities among the various command group locations.

2 AUDIO INSTRUMENTATION SYSTEM

A 20-channel audio recorder is positioned in the controller room to provide a complete audio record of command group activities during exercise play. The channels of the audio recorder are fed by area microphones, by taps on radios and telephones used in exercise play, by the computer system, and by a time code generator which imposes a continuous game time code on the audio tape. As with the video tape, the time code on the audio tape is vital to the synchronization of audio and video recordings for data collection and analysis.



● - AREA MICROPHONE

□ - VIDEO CAMERA

VCG - VIDEO CHARACTER GENERATOR

VCR - VIDEO CASSETTE RECORDER

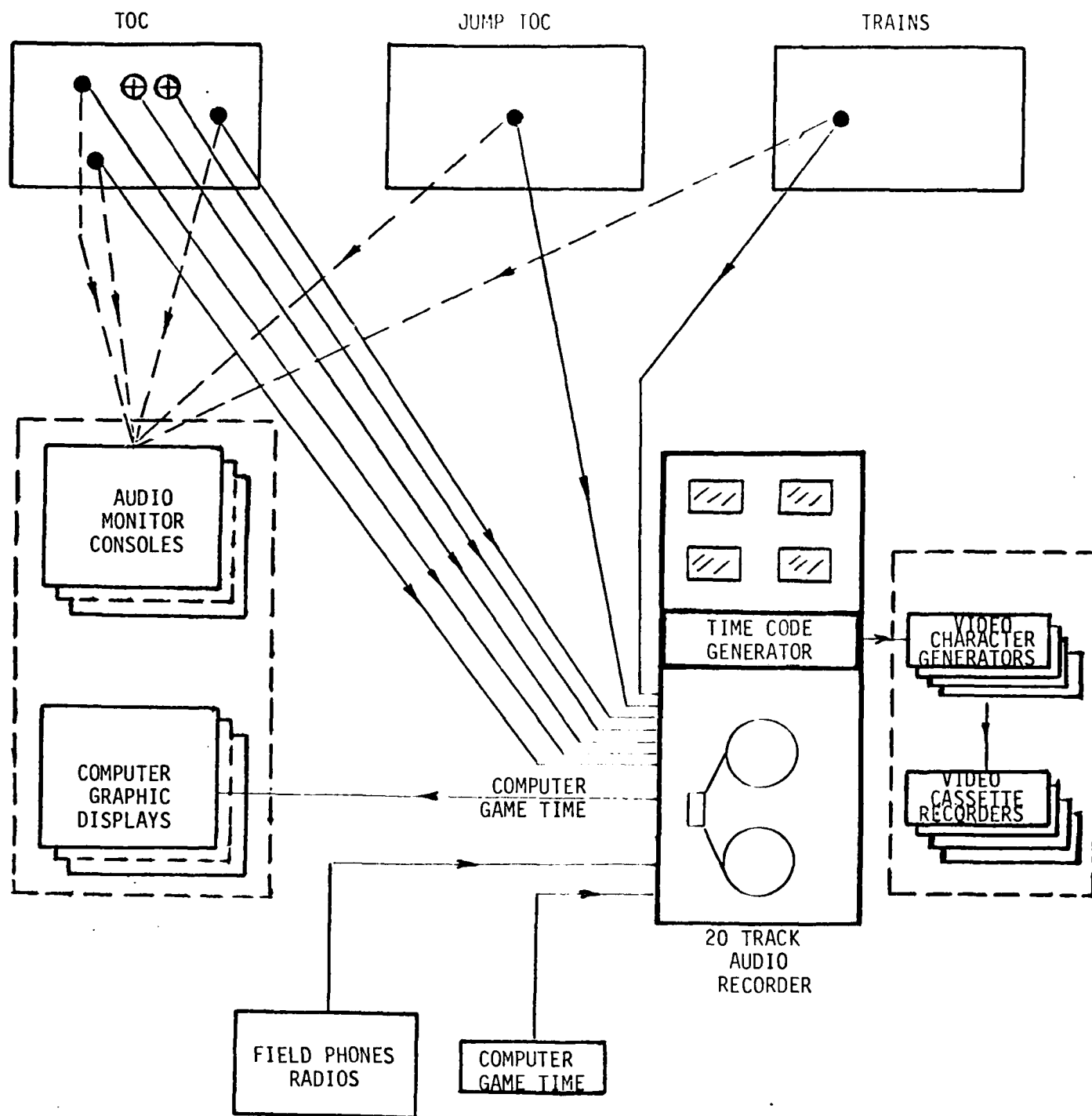
Figure D-1. CATTS INSTRUMENTATION - VIDEO
D-3

The audio recording system is diagrammed schematically in Figure D-2, and the channel allocation on the 20-channel recorder is diagrammed in Figure D-3.

3 ANALYST OBSERVATION STATIONS

In order to view and listen to data recorded on the video and audio tapes, SAI established two observation stations as diagrammed in Figure D-4. The only difference between the two stations is that Station 1 includes a 20-channel audio player and time code reader whereas Station 2 does not. Using the two observation stations, expert military consultants observe and interpret video and audio tapes to produce data necessary for behavior analysis.

Recorded data are stored in a laboratory data recording system for later manipulation and output for analysis.



- - AREA MICROPHONE
- ⊕ - CORDLESS MICROPHONE

Figure D-2. CATTS INSTRUMENTATION - AUDIO

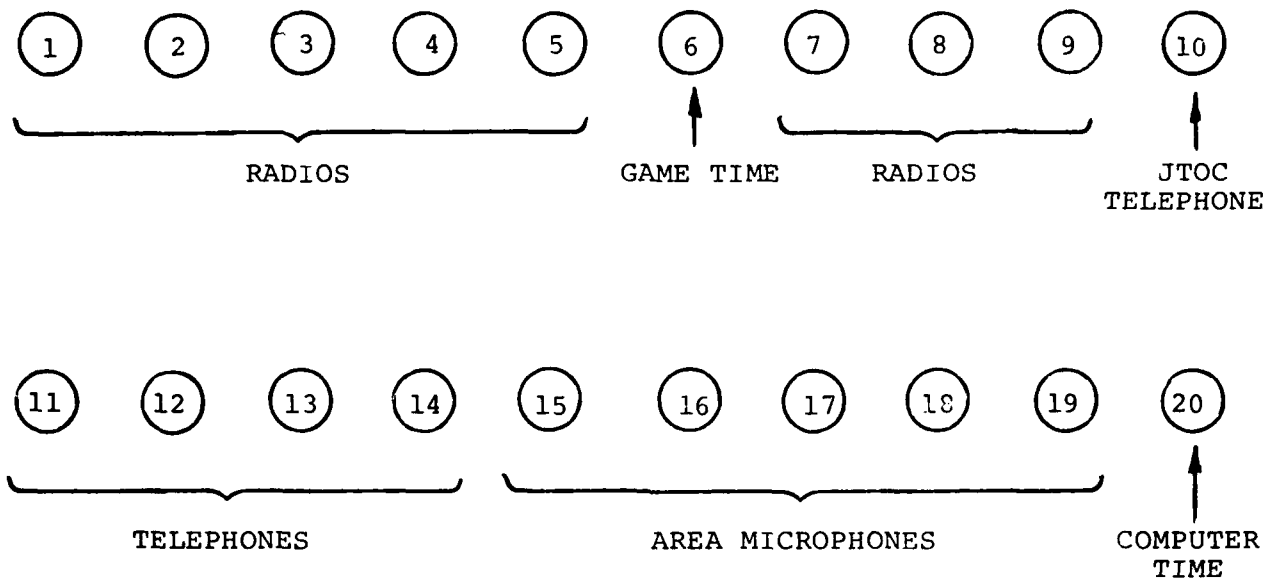


Figure D-3. AUDIO RECORDER CHANNEL ALLOCATION

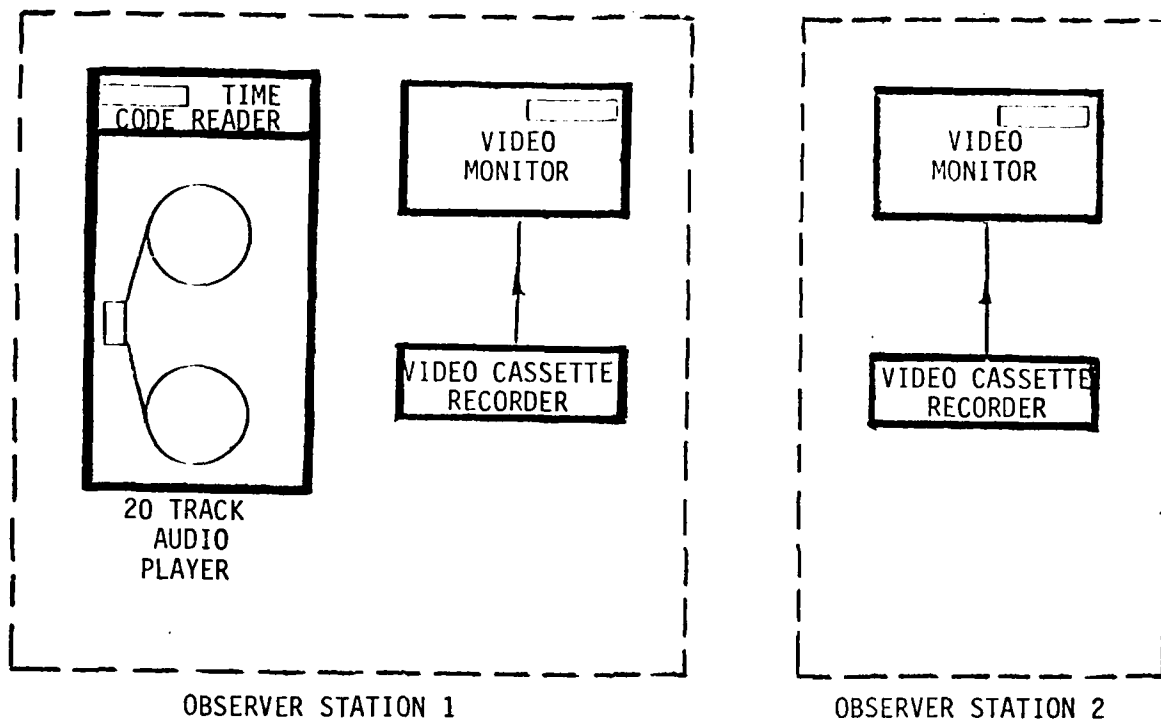


Figure D-4. ARI/SAI OBSERVATION STATIONS

APPENDIX E

PROBE DESIGNS

In response to contract tasking, probe designs were developed for application in CATTS exercises. The background for the development of these probes is presented in the annual Technical Report for the second contract year (paragraph 3.6.2). Although pilot probe designs were used in the development of these probes, neither of the two probes described in this appendix have been formally introduced into a CATTS exercise; nevertheless, their use is advocated with confidence. The probe designs are presented in worksheet format with complete information for their insertion and termination. Analysis of the probes would be conducted using the initial methodology advanced in Section 3 of the Technical Report.

E-1 DELAY PROBE DESIGN

The objective of the delay probe is to analyze and evaluate the actions of the battalion S2 section after receiving information of enemy activity which would threaten

an exposed flank of the battalion. Actions of the battalion commander and the balance of the command group would also be evaluated (Figure E-1).

E-2 ATTACK SCENARIO DESIGN

The objective of the attack probe is to analyze the behavior of the command group in response to an unanticipated battle event; namely, the encounter of a maneuver team (company) with an enemy minefield. Actions of the S3 Section, as well as the battalion commander, are key to maintaining the momentum of the attack operation (Figure E-2).

DATE 19 Apr 83 UNIT 1 BN 3 AR DAY 2

SCENARIO Irwin OPERATION Delay PROBE NUMBER 1

PROBE OBJECTIVE Analysis of the response behavior of a selected staff section (S2) in the performance of its function; analysis of battalion command group reaction to probe situation.

PROBE DESCRIPTION Unexpected enemy maneuver (flanking action).

OVERALL EXPECTED REACTION S2 should inform commander, S3 section, and affected maneuver units. S2 should confirm from other sources (e.g., adjacent unit, friendly air). Commander should take early and positive action to respond to threat.

I	TIME: 0430	INPUT: We received a SLAR report of 4 or 5 heavy tracked
N	MODE: R	vehicles at 585 970 moving in a NW direction at 8kph.
P	SENDER: Bde 2	
U	RECEIVER: S2	
T		
#	EXPECTED REACTION Inform commander, S3 section and subordinate units;	
1	attempt to confirm from other sources. Commander and S-3 should assess	
	the situation and consider courses of action to counter the threat.	

I	TIME: 0438	INPUT: My scouts report a great deal of dust at about
N	MODE: R	522 975. It looks like it's moving north.
P	SENDER: 1-77 S2	
U	RECEIVER: S2	
T		
#	EXPECTED REACTION S2 inform commander, S3 section, and subordinate units.	
2	Inform brigade S2. Commander issue warning order to affected units for	
	actions to protect the flank. Request artillery and air support.	

I	TIME: 0449	INPUT: We have a new location for those heavy tracked
N	MODE: T	vehicles at 515 982. They have stopped moving.
P	SENDER: Bde 2	
U	RECEIVER: S2	
T		
#	EXPECTED REACTION S2 inform commander, S3 section, and subordinate units	
3	and attempt to confirm.	

Figure E-1. DELAY PROBE

DATE 19 Apr 83 UNIT 1 BN 3 AR DAY 2
 SCENARIO Irwin OPERATION Delay PROBE NUMBER 1
 PROBE OBJECTIVE

PROBE DESCRIPTION

I	TIME: 0450	INPUT: We saw a cloud of dust to our southeast out of
N	MODE: R	sector about 5 minutes ago. It seems to be gone now.
P	SENDER: SCT LDR	
U	RECEIVER: S2	
T		
#	EXPECTED REACTION S2 inform commander, S-3, and brigade S-2. Continue	
4	efforts to obtain more information.	

I	TIME: 0452	INPUT: We can see that dust again. It appears to be
N	MODE: R	located about 510 980.
P	SENDER: SCT LDR	
U	RECEIVER: S2	
T		
#	EXPECTED REACTION Inform commander, S3, and brigade S-2. Continue efforts	
5	to obtain more information.	

I	TIME: 0458	INPUT: There are five T62's at 515 982 moving at a high
N	MODE: R	rate of speed to the southeast.
P	SENDER: EAGLE 6	
U	RECEIVER: S3	
T		
#	EXPECTED REACTION Inform commander, S2 section, brigade and unit to	
6	south.	

I	TIME: 0502	INPUT: Just got another SLAR report on those heavy track
N	MODE: T	vehicles. They are moving to the south, away from you
P	SENDER: Bde S2	at 522 975.
U	RECEIVER: S2	
T		
#	EXPECTED REACTION S2 inform commander and S3 section, and subordinate	
7	units; commander take necessary action to return situation to accomplish-	
	ment of original mission.	

Figure E-1. DELAY PROBE (Continued)

DATE 20 Apr 83 UNIT 1 BN 3 AR DAY 3

SCENARIO Fulda OPERATION Attack PROBE NUMBER 2

PROBE OBJECTIVE Analysis of the behavior of the battalion command group (including the commander) in responding to probe situation.

PROBE DESCRIPTION Encountering an unexpected obstacle (mine field).

OVERALL EXPECTED REACTION Rapid distribution of information, principally to commander and brigade. Prompt assessment of the situation, decision, and actions to sustain momentum of attack. Keep brigade, subordinate units, and adjacent unit informed.

I	TIME: 0445	INPUT: Our forward progress halted due to minefield at
N	MODE: R	540 120.
P	SENDER: Team C	
U	RECEIVER: S3	
T		
#	EXPECTED REACTION S3 inform commander, brigade, S2 and other subordinate	
1	units. S3 and commander consider alternative courses of action.	

I	TIME: 0454	INPUT: This field is extensive. It is impossible to
N	MODE: R	breach without major engineer support. We had better
P	SENDER: Team C	bypass this one.
U	RECEIVER: S3	
T		
#	EXPECTED REACTION Inform commander and S2. S3 request more information	
2	from Team C and then make recommendations to commander.	

I	TIME: 0502	INPUT: The minefield goes all the way north to the town
N	MODE: R	of Hunfeld. Request permission to leave sector and bypass
P	SENDER: Team C	to south.
U	RECEIVER: S3	
T		
#	EXPECTED REACTION S3 inform commander. Commander make decision on bypass.	
3	Request permission from brigade to leave sector. Commander issue warning order to Team C to prepare to bypass on order only.	

Figure E-2. ATTACK PROBE
E-5

DATE 20 Apr 83 UNIT 1 BN 3 AR DAY 3

SCENARIO Fulda OPERATION Attack PROBE NUMBER 2

PROBE OBJECTIVE

PROBE DESCRIPTION

OVERALL EXPECTED REACTION

I	TIME: 0506	INPUT: Permission to leave sector granted. Unit to your
N	MODE: T	south has been informed. Don't stay out there too long.
P	SENDER: BDE 3	
U	RECEIVER: S3	
T		
#	EXPECTED REACTION Commander order Team C to leave sector at 538 110 and	
4	bypass minefield. S3 coordinate with adjacent unit. S3 inform subordinate units.	

I	TIME: 0541	INPUT: We have bypassed the minefield, returned to sector
N	MODE: R	at 549 110 and continuing the attack.
P	SENDER: Team C	
U	RECEIVER: S3	
T		
#	EXPECTED REACTION Inform commander, brigade, subordinate units, and	
5	adjacent unit to south.	

Figure E-2. ATTACK PROBE (Concluded)

APPENDIX F

EXERCISE DATA

Outputs of data from video and audio recordings of CATTS simulation exercises were designed to facilitate analysis of command group behavior. The outputs were generated from data classified by expert military consultants and are stored on computer disk at the SAI facility in Leavenworth, Kansas. Samples of these outputs are displayed in this appendix (Figures F-1 through F-6). The outputs are identified as follows:

CATTS Data Collection (Figure F-1) - a listing of all interpreted data for each exercise.

Data Transfer Matrix (Figure F-2) - a time-ordered matrix of all data transfers for visual analysis of command group behavior.

CATTS DATA COLLECTION

UNIT: 3-99 INF
OBSERVATION DATE: 01/31/83
SCENARIO: F
HIGHER HQ: TF INE
GENERAL SUPPORT: 2-618 FA BN
PROBE: 0
PROBE DESCRIPTION: N/A

OBSERVER: GHY
EXERCISE DATE: 12/25/82
OPERATIONAL STATE: CF
LEFT ADJACENT: OTHER
DIRECT SUPPORT: 2-633 FA BN
RIGHT ADJACENT: 1-3 AR BN

START TIME			COMM MODE	RECEIVER		SENDER		DATA XFR TYPE	END TIME			BEHAVIOR	PROCESS	DURATION
HR	MIN	SEC		ID	RATING	ID	RATING		HR	MIN	SEC			
2	30	4	T	121		202		11	2	31	45	T	2	102
2	30	12	F	121		102		31	2	30	47	T	5	38
2	30	40	T	133		657		11	2	30	51	T	2	12
2	31	12	F	103		107		21	2	31	20	T	1	9
2	31	23	F	103		107		21	2	31	33	T	1	11
2	31	34	F	102		136		21	2	31	42	T	1	9
2	31	43	F	136		107		43	2	31	58	T	7	16
2	31	50	F	121		102		31	2	32	31	T	5	34
2	32	1	T	133		203		42	2	32	19	T	4	19
2	32	20	F	103		107		21	2	32	24	T	1	5
2	32	35	T	133		617		12	2	32	50	T	2	16
2	32	37	F	103		107		43	2	32	46	T	7	10
2	32	50	F	121		102		31	2	32	59	T	5	10
2	33	2	N	136		102		11	2	33	10	T	3	9
2	33	15	F	133		107		43	2	33	19	T	7	5
2	33	26	R	657		133		42	2	33	36	T	4	11
2	33	26	F	103		102		11	2	34	1	T	5	36
2	34	19	F	102		103		21	2	34	24	T	1	6
2	34	24		107		107		51	2	34	37	T	10	14
2	34	38	F	136		107		21	2	34	44	T	1	7
2	34	44	F	136		133		21	2	34	46	T	1	3
2	34	46	F	107		136		31	2	34	50	T	2	5
2	35	11	R	598		136		33	2	35	20	T	5	10
2	35	21		107		107		51	2	35	35	T	10	15
2	35	36	F	133		107		21	2	35	48	T	1	13
2	35	54	R	579		136		33	2	36	13	T	5	20
2	36	12	R	617		133		21	2	37	10	T	1	59
2	36	25	R	579		136		33	2	36	40	T	5	16
2	36	45	F	103		107		31	2	36	51	T	5	7
2	37	15	F	133		107		43	2	37	18	T	7	4
2	37	20	F	133		107		31	2	37	30	T	1	21
2	37	42	F	133		107		43	2	37	53	T	7	12
2	37	44		107		107		51	2	38	10	T	1	27
2	37	49	R	631		136		21	2	38	5	T	1	17
2	37	56	R	617		133		42	2	38	43	T	4	48
2	38	4	F	103		107		31	2	38	19	T	5	15
2	38	12	F	136		107		21	2	38	16	T	1	5
2	38	19	F	136		102		21	2	38	31	T	1	13
2	38	40	F	107		133		12	2	38	42	T	6	3
2	38	45	F	136		107		31	2	39	6	T	5	24
2	39	9	F	121		102		31	2	39	27	T	5	19
2	39	9	F	107		136		31	2	39	35	T	5	27
2	39	14		103		103		51	2	39	43	T	10	30

Figure F-1. CATTS DATA COLLECTION (Sample)

Command Group Observation Report (Figure F-3) - a series of outputs for analysis of command group behavior. Most reports include number, duration, frequency, and duration ratio of data transfers. Figure F-3 shows intra-staff section and inter-staff section interactions as well as interactions between a command group and external organizations.

Process Matrix (Figure F-4) - a time-ordered matrix of all staff processes for visual analysis of command group behavior.

Command Group Behavior (Process) Report (Figure F-5) - a series of outputs for analysis of command group behavior. The reports present all ten staff processes identified by individual and team behavior as well as by number, duration, frequency, and duration ratio.

CATTS Battle Outcome Report (Figure F-6) - the presentation of opposing force

DYADIC ACTIVITY SUMMARY										
		R E C E I V E R								
		CO	S1	S2	S3	S4	HHQ	ADJ	LOWR	SUFT
	CO	0	1	25	168	1	0	0	9	0
S	S1	2	0	1	4	41	13	0	4	0
E	S2	6	1	27	69	0	21	0	1	0
N	S3	51	4	72	118	3	28	0	84	46
D	S4	3	23	0	17	0	16	0	4	0
E	HHQ	0	3	9	22	2	0	0	1	1
R	ADJ	0	0	0	0	0	0	0	0	0
	LOWR	7	26	1	194	40	2	0	0	0
	SUFT	0	0	0	12	0	0	0	0	0

Figure F-3. COMMAND GROUP OBSERVATION REPORT (Sample)

PROCESS EFFORT

BEHAVIOR	PROCESS	SECTION	NUMBER	DURATION	FREQUENCY	DURATION RATIO
181	1 SLEAKING INFORMATION	CO	67.	885.	0.3304	0.0745
		S1	31.	513.	0.1566	0.0432
		S2	41.	786.	0.2071	0.0662
		S3	149.	2538.	0.7525	0.2136
		S4	22.	295.	0.1111	0.0248
		TOTAL	310.	5017.	1.5855	0.4223
	2 RECEIVE INFO	CO	0.	0.	0.0000	0.0000
		S1	24.	520.	0.1212	0.0438
		S2	7.	303.	0.0754	0.0255
		S3	149.	3009.	0.7525	0.2533
		S4	34.	706.	0.1717	0.0594
		TOTAL	214.	4538.	1.0807	0.3820
	3 CONSIDER ACTION / DECISION	CO	0.	0.	0.0000	0.0000
		S1	0.	0.	0.0000	0.0000
		S2	0.	0.	0.0000	0.0000
		S3	0.	0.	0.0000	0.0000
		S4	0.	0.	0.0000	0.0000
		TOTAL	0.	0.	0.0000	0.0000
	4 IMPLEMENTING DECISION	CO	2.	74.	0.0101	0.0062
		S1	0.	0.	0.0000	0.0000
		S2	0.	0.	0.0000	0.0000
		S3	16.	228.	0.0808	0.0192
		S4	0.	0.	0.0000	0.0000
		TOTAL	18.	302.	0.0909	0.0254
	5 COORDINATING ACTIVITIES	CO	25.	775.	0.1263	0.0652
		S1	16.	499.	0.0808	0.0420
		S2	31.	1028.	0.1566	0.0865
		S3	92.	2228.	0.4646	0.1875
		S4	11.	466.	0.0556	0.0392
		TOTAL	175.	4996.	0.8838	0.4205
	6 TRANSMITTING INFORMATION	CO	43.	492.	0.2172	0.0414
		S1	13.	301.	0.0657	0.0253
		S2	52.	1233.	0.2626	0.1038
		S3	129.	1942.	0.6515	0.1635
		S4	26.	862.	0.1313	0.0726
		TOTAL	263.	4830.	1.3282	0.4065
	7 SUPERVISING THE STAFF	CO	63.	711.	0.3182	0.0598
		S1	1.	32.	0.0051	0.0027
		S2	0.	0.	0.0000	0.0000
		S3	6.	37.	0.0404	0.0031
		S4	1.	14.	0.0051	0.0012
		TOTAL	73.	794.	0.3687	0.0668
	8 REQUEST RESOURCES/SUPPORT	CO	0.	0.	0.0000	0.0000
		S1	0.	0.	0.0000	0.0000
		S2	0.	0.	0.0000	0.0000
		S3	10.	368.	0.0505	0.0310
		S4	3.	65.	0.0152	0.0055
		TOTAL	13.	433.	0.0657	0.0364
	9 RECEIVE ORDERS	CO	0.	0.	0.0000	0.0000
		S1	0.	0.	0.0000	0.0000
		S2	0.	0.	0.0000	0.0000
		S3	0.	0.	0.0000	0.0000
		S4	0.	0.	0.0000	0.0000
		TOTAL	0.	0.	0.0000	0.0000
	10 ASSESS SITUATION	CO	24.	762.	0.1212	0.0641
		S1	12.	478.	0.0606	0.0402
		S2	3.	240.	0.0152	0.0202
		S3	2.	132.	0.0152	0.0111
		S4	24.	1205.	0.1212	0.1014
		TOTAL	64.	2817.	0.3335	0.2371
	TOTAL INDIVIDUAL AND TEAM ALL PROCESSES	CO	224.	3699.	1.1312	0.3113
		S1	97.	2343.	0.4899	0.1972
		S2	134.	3590.	0.6767	0.3022
		S3	556.	10482.	2.8078	0.8822
		S4	121.	3613.	0.6111	0.3041
		TOTAL	1132.	23727.	5.7167	1.9971

Figure F-5. COMMAND GROUP BEHAVIOR REPORT (Sample)

F-7

BLUE					RED				
2120: 0		5137: 0		EQUIPMENT	2120: 0		5137: 0		
NUMBER	URE	NUMBER	URE		NUMBER	URE	NUMBER	URE	
417	834	391	782	FIFLL	906	1812	392	1784	
24	120	20	100	LMG	84	420	77	385	
0	0	0	0	MOUNTED LMG	0	0	0	0	
0	0	0	0	50 CAL MG	0	0	0	0	
82	164	62	124	LAW/SG-9	9	126	7	98	
20	780	11	429	BRADON/RTG-7	81	1377	66	1122	
0	0	0	0	TOW/SARGEI	9	180	8	160	
19	855	9	405	APC W/MSL	0	0	0	0	
29	551	13	242	APC IMF	3	60	0	0	
0	0	0	0	RTG-60	81	1420	30	600	
0	0	0	0	HEM W MSL	0	0	0	0	
0	0	0	0	HEM W/O MSL	24	562	11	253	
26	1898	11	803	M60A1/T-62	30	3120	9	720	
0	0	0	0	M60A2/T-72	0	0	0	0	
6	180	5	150	81/100MM MT	3	75	3	75	
3	96	2	64	107/120MM MT	18	630	18	630	
5	125	5	125	VULCAN/ZSU23	3	75	3	75	
0	0	0	0	MKL	0	0	0	0	
0	0	0	0	HOWITZER	0	0	0	0	
0	0	0	0	LNG RKG MSL	0	0	0	0	
6	6	5	5	TRUCK	21	21	21	21	
637	5609	534	3234	TOTAL	1281	10098	1145	5923	
523	523	486	486	PERSONNEL	1414	1414	1359	1359	
FORCE RATIO				RELATIVE EXCHANGE RATIO				SMRRT	
2120: 0 - 0.5555		5137: 0 - 0.5460		0.9662				-0.0149	
FROM 2120: 0 TO 5137: 0									
CASUALTIES				LOSS EXCHANGE RATIO		AIR MISSIONS		SUPPORT FIRE MISSIONS	
BLUE	EQUIPMENT	RED		EQUIPMENT		BLUE	RED	BLUE	RED
NUMBER	URE	NUMBER	URE	1.7238		15	12	53	103
106	2538	140	4375	PERSONNEL					
PERSONNEL				1.4103					
39	39	55	55						

Figure F-6. CATTS BATTLE OUTCOME REPORT (Sample)

structure of personnel and equipment as well as the computations of battle outcome based on relative loss exchange ratio (RER), loss exchange ratio (LER), and surviving maneuver force ratio differential (SMFRD).