PROCEEDINGS OF
OPERATIONAL TRAINING RESEARCH AND DEVELOPMENT CONFERENCE:
Anti-Air Warfare - 1

Jointly Sponsored by

Office of Naval Research
Bureau of Naval Personnel
and
Naval Training Device Center

HSR-RR-63/28-Sd

December 1963

human sciences research inc
WESTGATE INDUSTRIAL PARK
POST OFFICE DRAWER 370 McLEAN, VIRGINIA

HSR-3050-C-2/Sd
51 Confidential Pages
Copy 14 of 75 copies

This material contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18, U. S. C., Sections 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law.

GROUP - 4
Downgraded at 3 year intervals;
declassified after 12 years

PROCEEDINGS OF

OPERATIONAL TRAINING RESEARCH AND DEVELOPMENT CONFERENCE.

Anti-Air Warfare - 1

Jointly Sponsored by:

Office of Naval Research
Bureau of Naval Personnel
and
Naval Training Device Center

HSR-RR-63/28-Sd

December 1963

Compiled by Human Sciences Research, Inc., operating under Contract Nonr. 4038(00) with the Personnel and Training Branch of the Office of Naval Research

FOREWORD

This report is a compilation of sixteen (16) papers covering various topics in the general area of operational training research. These papers ~~consist of verbatim and summary presentations given~~ by individuals from 12 different organizations which include both U. S. Navy and civilian contract agencies. These presentations were delivered at a training research conference during the period 31 October and 1 November 1963. The training research conference was jointly sponsored by the Office of Naval Research, Bureau of Naval Personnel and the ~~Naval~~ Training Device Center and was hosted by Human Sciences Research, Inc., located in McLean, Virginia.

The training research conference provided an opportunity for interested Navy-experienced research personnel to describe their past and current research projects and to participate in discussion relevant to the conference objectives. The primary objective of the conference was to obtain current research status information which would serve as initial inputs towards the construction of a Navy-wide coordinated Operational Training Research and Development Program.

This report includes copies of the formal presentations given at the conference but not discussion and summary remarks. These informal comments are stored on tape and are being extracted for use as inputs to the next training research conference planned to be held at Princeton University sometime between mid-January and mid-February, 1964.

The 16 papers given at the training research conference are grouped into five sections in this report. The basis for grouping is both one of convenience and because the organization does reflect fairly common topics or subject matter areas.

Section A consists of 4 papers dealing specifically with topics directly relevant to the initial steps taken in the construction and implementation of a Navy-wide Operational Training Research and Development Program. The first is by Dr. Glenn Bryan of the Training Research Branch of ONR and covers the background actions and decisions which led to the formulation of an outline plan for an operational training R/D program. It also briefly describes the sequential tasks contained in the skeleton plan. Dr. John A. Whittenburg, of Human Sciences Research, Inc. describes the approach and initial results of the first task specified in the plan, the development of behavioral specifications for key personnel and subteams in AAW. Then, Dr. Edward Weiss of the Matrix Corporation, discusses the current progress and approach being taken in the conduct of the second task specified in the plan, a study of procedures and research planning for AAW training programs. The section is concluded by Mr. John Nagay of the Office of Naval Research. He presents some of the major requirements and functions to be accomplished in attaining an effective coordinated Navy-wide operational training R/D program.

Section B consists of five papers. These describe relevant past, current, and planned research programs of the Office of Naval Research, the Naval Training Device Center, and the Bureau of Naval Personnel. The ONR program is described by Dr. Bryan. Dr. James Regan of the Naval Training Device Center identifies projects in the NTDC program which relate, in varying degrees, to the general area of operational training. Mr. Sid Friedman of the Bureau of Naval Personnel briefly indicates the many and diversified research projects of the Bureau of Naval Personnel which are relevant to the plan. Dr. Earl Jones of the Personnel Training Research Laboratory discusses past and current research tasks conducted by the laboratory and emphasizes many of the problems associated with the conduct of training research and implementation of findings into the Navy's on-going training programs. This is followed by Dr. Edward Rundquist's account of some of the current exploratory efforts being undertaken in curriculum development and highlights plans for future research.

Section C consists of four papers dealing with current research projects and exploratory studies in the general area of decision making. The first, by Dr. Ray Sidorsky of Electric Boat, a division of the General Dynamics Corporation, describes the experimental facilities, problem approach and initial findings of his current research program. The objective of this research is to develop systematic procedures and aids for training personnel in the area of tactical decision making. The next paper by Dr. Harold Schroder of Princeton University describes a conceptual orientation and some research findings on tactical decision making. He pointed out that the research program has potential implications for both selection and training of tactical decision makers at various levels of command. The third paper by Dr. R. M. Hanes of Applied Physics Laboratory summarizes the results of dynamic simulation studies leading to recommendations regarding the role of computers as tactical decision aids to the Fleet Anti-Air Warfare Commander in AAW. The fourth presentation by Dr. Robert Kinkade of Aircraft Armaments, Inc. briefly covers the results and implications of some of his recent exploratory studies in tactical decision making.

Section D consists of two papers which present recently completed research in the area of team performance and training. The first by Dr. George Briggs of Ohio State University reports the findings of a study concerning the affects of altering various team and task variables on team performance. The second paper is a joint presentation given by Dr. Robert Glaser and Dr. David Klaus of the American Institute of Research. Part I of the paper sets forth the methodology and approach taken to investigate team behavior in a laboratory environment. It goes on to describe the exploratory studies which demonstrate the effectiveness of the laboratory environment as a suitable setting for investigating team behavior. The second part of the paper summarizes a number of studies designed to determine the affects of such variables as team composition, reinforcement schedule, prior individual training and individual ability on team performance. These studies should provide a better understanding of the factors that affect team learning and ultimately toward the development of effective team training methods and techniques.

The last section of the report, Section E, contains a paper given by Dr. Joseph Rigney of the University of Southern California. It is a product of a joint effort by Dr. Glenn Bryan of the Office of Naval Research and Dr. Joseph Rigney. It contains a proposed concept to handle several of the recognized problems encountered in attempting to train and maintain a high degree of personnel readiness in the operational environment. This concept was presented to get reactions and suggestions from the various participants. It is planned to elaborate and modify the concept with continued exposure to both operational and cognizant research personnel.

List of Attendees to AAW Conference

Hosted by Human Sciences Research, Inc. - October 31 & November 1, 1963

Office of Naval Research

Dr. Glenn L. Bryan
Head, Personnel and Training Branch
Psychological Sciences Division
Office of Naval Research
Code 458, T-3 Building (Room 2701)
Washington 25, D. C.

Mr. John A. Nagay
Personnel and Training Branch
Psychological Sciences Division
Office of Naval Research
Room 2701, T-3 Building
Washington 25, D. C.

Dr. Richard Trumbull
Director, Psychological Sciences Division
Office of Naval Research
Room 2038, T-3 Building
16th & Constitution Ave., N. W.
Washington 25, D. C.

Mr. Luigi Petrullo
Office of Naval Research
Room 2703, T-3 Building
Washington 25, D. C.

Naval Training Device Center

Dr. James J. Regan
UNS Training Device Center
Post Washington, New York

Dr. Clayton K. Bishop
Head, Crew Training Branch
USN Training Device Center
32 Pewter Lane
Hicksville, New York

Mr. Emerson Dodds
USN Training Device Center
Port Washington, New York

Bureau of Naval Personnel

Mr. Sidney Friedman
Bureau of Naval Personnel
Room 3736
Arlington Annex
Columbia Pike & Arlington Ridge Road
Arlington, Virginia

Dr. Earl I. Jones
USN Personnel Research Field Activity
San Diego 52, California

Dr. Edward A. Rundquist
USN Personnel Research Field Activity
San Diego 52, California

Mr. Alan A. Sjoholm, Head
New Developments Research Branch
Personnel Research Division
Bureau of Naval Personnel
Pers-153
Naval Annex Building, Room 3727
Washington 25, D. C.

Institute of Defense Analysis

Dr. Henry W. Sinaiko
Institute of Defense Analysis
407 Glasgow Road
Alexandria, Virginia

University of Southern California

Dr. Joseph Rigney
University of Southern California
7953 4th Street
Downey, California

Matrix Corporation

Dr. Ed Weiss
Matrix
507 18th Street, S
Arlington, Virginia

Mr. Jack Scopino
Matrix
507 18th Street, S
Arlington, Virginia

Mr. Kenneth Lawrence
Matrix
507 18th Street, S
Arlington, Virginia

Princeton University

Dr. Harold Schroder
Department of Psychology
Princeton University
Princeton, New Jersey

Ohio State

Dr. George E. Briggs
OSU Research Foundation
Ohio State University
1314 Kinnear Road
Columbus 12, Ohio

Electric Boat

Dr. Raymond C. Sidorsky
Head, Human Factors Section
Electric Boat Division
General Dynamics Corporation
Groton, Connecticut

Applied Physics Laboratory

Dr. Jack W. Gebhard
Applied Physics Laboratory
Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Maryland

Dr. Randall M. Hanes
Senior Research Psychologist
Applied Physics Laboratory
Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Maryland

University Of Pittsburgh

Dr. Robert Glaser
University of Pittsburgh
Department of Psychology
Pittsburgh 13, Pennsylvania

Dr. David J. Klaus
American Institute of Research
University of Pittsburgh
410 Amberson Avenue
Pittsburgh 32, Pennsylvania

Aircraft Armaments, Inc.

Mr. Robert Kinkade
Aircraft Armaments, Inc.
York Road
Cockeysville, Maryland

Human Sciences Research, Inc.

Dr. John A. Whittenburg
Vice President
Human Sciences Research, Inc.
P. O. Drawer 370
Westgate Industrial Park
McLean, Virginia

Dr. M. Dean Havron
Technical Director
Human Sciences Research, Inc.
P. O. Drawer 370
Westgate Industrial Park
McLean, Virginia

Dr. Willard S. Vaughan
Vice President
Human Sciences Research, Inc.
P. O. Drawer 370
Westgate Industrial Park
McLean, Virginia

TABLE OF CONTENTS

BACKGROUND FOR THE CONFERENCE

Glenn L. Bryan

There are a number of reasons why this conference was called:

1) to provide an opportunity for those conducting research related to AAW to meet together, get acquainted, and open up new channels of communication;

2) to exchange research information;

3) to identify common and/or critical problems of AAW training and/or training research;

4) to invite each of you to participate in an integrated, cooperative AAW research program; and

5) to seek your assistance in developing effective procedures that will allow us to work effectively together in prosecuting that program.

That is quite an order for a single two-day meeting. However, if this meeting is successful, it should be the first of a series which should contribute greatly to the achievement of these goals.

In order that we all start out with the same background information, let us review briefly the events which have led up to this meeting. Since this is an informal meeting, allow me to relate this in the way that it happened from my own point of view.

For me it all started about 15 years ago when I had the opportunity to participate in a series of studies that included the observation and analysis of Combat Information Centers. At that time it became apparent that the officers and men who were attempting to counter the air threat were faced with a very difficult job at which many were inadequate. Perhaps even worse, even though they were aware of that fact, it was next to impossible for them to get sufficient amounts of the right kinds of training to overcome their deficiences for that matter, there were strong suspicions that appropriate training facilities and procedures did not exist. Even the fleet training exercise, the bulwark of operational team training in the Navy, left a great deal to be desired. It was usually difficult for certain of those in CIC to know what they were doing wrong, what they were doing right, or to know exactly what they had done when the exercise was over.

Following that experience, the efforts of the RAND Corporation and of the System Development Corporation to develop new training facilities and procedures for the Air Force in support of their air defense training were watched with great interest. These efforts emphasized the importance of team training and demonstrated the effectiveness of a number of experimentally-derived training principles. Furthermore, experimental studies that were being carried out at the Naval Research Laboratory and later at the Applied Physics Laboratory provided convincing proof that operational team training could benefit from laboratory research, despite its complexity.

As a consequence of this background I was "fair game" for the Chief of Staff of the Atlantic Training Command who was seeking to attract more research attention to the problems of operational team training. One impressive feature of his interest was that he seemed eager to get psychologists to work on real problems and yet was willing to let them attack these problems in the manner in which they had been trained. It is unnecessary to point out to most of you here that this attitude is not altogether common.

Preliminary discussions with representatives of the Training Command led to the establishment of an ad hoc committee Captain A. L. Shepherd, ComTraLant; Mr. Sidney Friedman, Bureau of Naval Personnel; Dr. James Regan, Naval Training Device Center; and the Commanding Officer at Dam Neck (originally Captain Green and later Captain Balch) and myself. In order to take advantage of experiences gained in connection with the system training program for the Air Force and in their own team training experiments at Princeton, Dr. John Kennedy and Dr. Harry Schroder were invited to participate in the series of committee meetings. Arrangements for their participation were made through the Group Psychology Branch of the Office of Naval Research which sponsored the Princeton studies.

This committee reviewed the reports of ONR study groups and of the Joint Atlantic and Pacific Fleet Symposium on AntiAir Warfare. They also entered into discussions with the training personnel at Dam Neck. After several meetings, it was decided that the situation warranted examination by a full-time consultant who could devote several days to an analysis of present and future team training requirements and submit a written report to the committee containing his comments and recommendations. Dr. Robert Chapman of Thompson Ramo Wooldridge was asked to serve in this capacity. He spent several days at Dam Neck collecting information and then appeared before the committee to present his findings and recommendations. This report was submitted through channels by the Training Command, Atlantic, in order to get reactions -- and it got some. Most of these stemmed from the fact that the consultant's report was misunderstood to be a specific proposal as opposed to a general approach.

Consequently, as a member of the committee, I was asked to provide clarification and further details. To generate further information, Dr. Joseph Rigney of the Electronics Personnel Research Group at the University of Southern California was asked to visit Dam Neck and submit a separate report. Armed with the report submitted by Dr. Chapman and the report submitted by Dr. Rigney; Mr. Friedman, Dr. Regan, and I met together to evolve a version of the plan upon which we could all agree and which each would be willing to back with his own resources.

Although the resulting plan was not intended to be any more than a specification of the plan already submitted up through channels, it was regarded as an alternative plan and we were urged to make it a matter of official record. This was done by means of a presentation to the Standing Committee for Personnel Training and Readiness. It was then sent to the Chief of Naval Operations requesting that it be reviewed and approved. After extensive review, approval was granted to implement the first portion of the plan and ONR was assigned management responsibility.

Before proceeding with a description of the plan itself, I would like to discuss the guidelines that were used in laying it out. First of all, it should be made clear that the ultimate goal of the plan is to improve AAW Readiness. It seeks to do this by improving training at all levels of responsibility, for teams and for individuals, ashore and afloat. The plan is to incorporate both basic and applied research. All of the research, basic as well as applied, is to be undertaken within a frame-work such that the potential contribution of each has a specified relationship to the program as a whole.

One of the considerations which was a matter of some concern was the cost of supporting the training system that might eventuate from future research. For, if history has taught us anything about operational team training in this area, it has taught us that the costs of supporting such training can be quite high. Consequently, it is most important to make provision for adequate support of any new training system from the outset. I, personally feel that many of the current training systems suffer from the lack of adequate support. It would be indeed unfortunate if a new system was developed and failed to realize its full potential because its support requirements had not been foreseen.

Other characteristics related to the support plan are shown in the accompanying slide.

Desired Characteristics of An
AAW Training Support Program

Once Developed, It Should Be --

Self-sufficient

Adaptable

A Navy-manned, in-service program

Feasible in its technical, hardware, and dollar demands.

The decision to specify that the training program to be developed should be capable of being supported by Navy personnel was based upon knowledge that the Navy was unwilling to become dependent upon any specialized civilian organization. Many reasons were given for this unwillingness which won't be gone into at this time. The training system should be self-sufficient enough to allow it to function adequately even if some other system fails. It should be sufficiently adaptable to accommodate great changes -- because changes will occur over the years. It should be manned by Navy personnel and course materials should be produced by Navy personnel. In all aspects it should be feasible in its technical, hardware and dollar demands. However, it should be emphasized that there is a big job to be done and it won't be quick, cheap, or easy.

So far we have been talking about the support required by the training program itself. Let us now shift to some consideration of the research plan which is expected to produce a new training program or to improve existing ones.

A research effort capable of doing this is apt to be reasonably large. It has to be managed somehow. There seemed to be four general ways that such a program could be managed. One, a contractor can be selected and given the responsibility conducting whatever research was necessary. He would be provided with the funds necessary to support his effort. Two, a kind of Special Projects organization might be set up and given the authority and the resources to develop a new training program. Three, the situation could be left as it is. After all, some research related to AAW gets done at the present time. By and large it is good research, conducted by competent people. However, it is largely uncoordinated. It isn't entirely clear how it all fits together. This leads to the fourth possibility, which is to knit together the efforts of the people who are capable of doing research in the area, the researchers with extensive backgrounds and contacts within the Navy and in AAW. This fourth approach would seek to utilize existing research capabilities and budgets to a maximum. The purpose of this meeting is to explore the possibility of working out the details of procedures for developing a Navywide integrated research program. The plan would involve both military and civilian efforts, in-service and contractor, operators and trainers.

So much for the guidelines that were agreed upon as the framework within which the training and the training research should be carried on. Now to get to the plan itself.

It consists of 9 tasks. These are presented below.

.01 Statement of Behavioral Specifications for AAW Training

.11a Develop AAW Training Research Program Plan

.11b Systems Analyses of AAW Training Requirements

.12 Consider Implications of USAF Air Defense Training Program

.13 Develop Criterion Measures of AAW Operational Proficiency

.20 Develop and Evaluate Conceptual Design for New Training Materials and Methods in AAW

.21 Develop Support Material for AAW Operational Training

.22 Develop and Test AAW Student Selection and Classification Procedures

.30 Conduct Final Test and Evaluation of the Newly-developed AAW Training Systems

The numbers that appear before the titles of the tasks indicate the order in which they should be undertaken. The fact that some of them have identical first digits indicate that they can be paralleled. Each task is designed to produce useful information in its own right in addition to contributing to later tasks. Each task is small enough that any of the funding organizations involved could accommodate any one of them without major reprogramming. This division into tasks of this size make it relatively simple for the three funding groups to divide the program up using different research groups and different funds.

It is important to recognize that the plan listed is a minimum plan. If it is undertaken, it will contribute to the improvement of current training and the development of improved training procedures. However, it is intended to serve still another function -- that of providing a focus for the many different types of research that are being conducted that could, and should, have a bearing on AAW operational team training. One way of thinking of it is to think of the 9 tasks as vertibrae that make up a backbone. The other research may be related to the backbones as ribs. And, in that indirect way, the ribs become related to each other.

Such a structure permits those attempting to program research to detect gaps and note relationships. As we will learn during the course of this meeting, it is hoped that it will provide the basis for a cooperative research enterprise of substantial proportions.

The first of the tasks listed has been completed. It was accomplished by Dr. Whittenburg of Human Sciences Research. They are currently continuing their work on extensions of their original findings. Dr. Weiss of the MATRIX Corporation has been pursuing the task indicated as .11a for the past several months. I shall not attempt to describe these tasks at this time since they will be presented in some detail by their investigators shortly. Task .11b is planned for later this year in connection with the Naval Training Devices Center's research program. Generally speaking, it involves the application of operations research techniques to guide training research. It seeks to indicate where training research is most needed and to guide the investment of training research dollars where they will do the most good.

Task .12 embodies one of the unusual features of the plan. Its primary purpose is to set aside some funds to obtain advise from those who have learned the lessons that the Air Force's experience had to teach. But, in addition, it will serve to pay consulting fees to any investigator who needs assistance from a previous investigator in interpreting his reports or to assist with the detailed planning for the execution of some follow-up task taking full advantage of the experienced gained in the conduct of the previous research. Investigators who join the plan agree, in advance, to provide consulting assistance of this type to other investigators. Where required these consulting services will be furnished by ONR.

Task .13 covers the development of performance criteria for the individual jobs involved in AAW and for the performance of the AAW system itself. With appropriate criterion measurement techniques, it will be possible to compare various methods of training. Hopefully, it will also provide diagnostic information which will reveal strengths and weaknesses of each specific training procedure.

Task .20 seeks to develop in detail the conceptual design for a new training system. This design can be examined and evaluated from many points of view as a concept before expensive hardware is developed. Once the conceptual design is perfected the next step is the straightforward implementation of the concept.

Task .22 may not prove to be necessary. Or, it may simply be a matter of developing appropriate standards for selecting individuals for the various billets involved in AAW.

The last task anticipates the final test and evaluation of the training system. This involves more than an examination of its output. It will seek to examine thoroughly the characteristics of the training system, including such things as its capacity, flexibility, breakdown points, etc.

The Chief of Naval Operations has approved the plan for implementation through Task .13. I think that it is evident that the plan is progressing. We will soon be preparing an account of its current status for presentation to CNO, COMTRALANT, COMTRAPAC, and other representatives of the military offices involved.

The ultimate success of the plan is dependent upon close and continued cooperative effort among people who tend to be distinguished more for jealously guarded independence in their research rather than for their cooperative research efforts. It may be naive to pin the hopes of the plan upon such an unlikely consideration. However, I do not really think this is so. It seems to me that achievements to date indicate that such an approach is not only feasible but well on the road to realization.

Behavioral Specifications for Key AAW Personnel and Subteams in the CIC/WCS Complex *

John A. Whittenburg
Human Sciences Research, Inc.

The topic of my presentation is behavioral specifications. In brief, behavioral specifications serve to describe the operational performance characteristics associated with proficient personnel. Explicitly defined behavioral specifications provide a foundation for deriving realistic training objectives.

With that short introduction, I would like to focus a number of the following remarks around Chart 1, entitled, "Variable Domain for Behavioral Specifications." This chart will be used as a basis for:

1. Expanding the definition of behavioral specifications.
2. Discussing the methodological approach taken in this study.
3. Identifying the study scope and relative research emphasis.
4. Introducing some of the key concepts used in this study.

Inspection of the Chart reveals four descriptive categories. Category One (functional requirements) deals with the question of what is the "job" to be performed. Category Two (personnel levels) is concerned with the question of who performs the "job". Category Three (contextual variables) deals with the question of where or in what context the "job" is to be performed. Category Four (performance criteria) is concerned with the question of how or in what terms the required performance may be described. In substance,

* The material used in this presentation was taken from the following reference.

Whittenburg, John A., Cavonius, Carl R., Harper, Walter R., and Bailey, Gerald C. Behavioral specifications for key AAW personnel and subteams in the CIC/WCS Complex. McLean, Virginia: Human Sciences Research, Inc. July 1963. HSR-RR-63/16-Sd (CONFIDENTIAL)

Chart 1

VARIABLE DOMAIN FOR BEHAVIORAL SPECIFICATIONS

Functional Requirements	Personnel Levels	Contextual Variables	Performance Criteria
Mission **Phases** **Functions** **Tasks**	Command & Control Inter-Team Teams Sub-Teams Individuals	<u>Operational Variables</u> 1. Raid characteristics 2. Environmental conditions <u>System Variables</u> 1. System operating characteristics 2. Derived system operating procedures <u>Tactical Variables</u> 1. Assigned mission 2. Doctrine	<u>Operational Criterion</u> Information processing rate <u>Training Criteria</u> Go/No Go Accuracy Completeness Time Quality

there are four kinds of considerations included in the development of a behavioral specification:

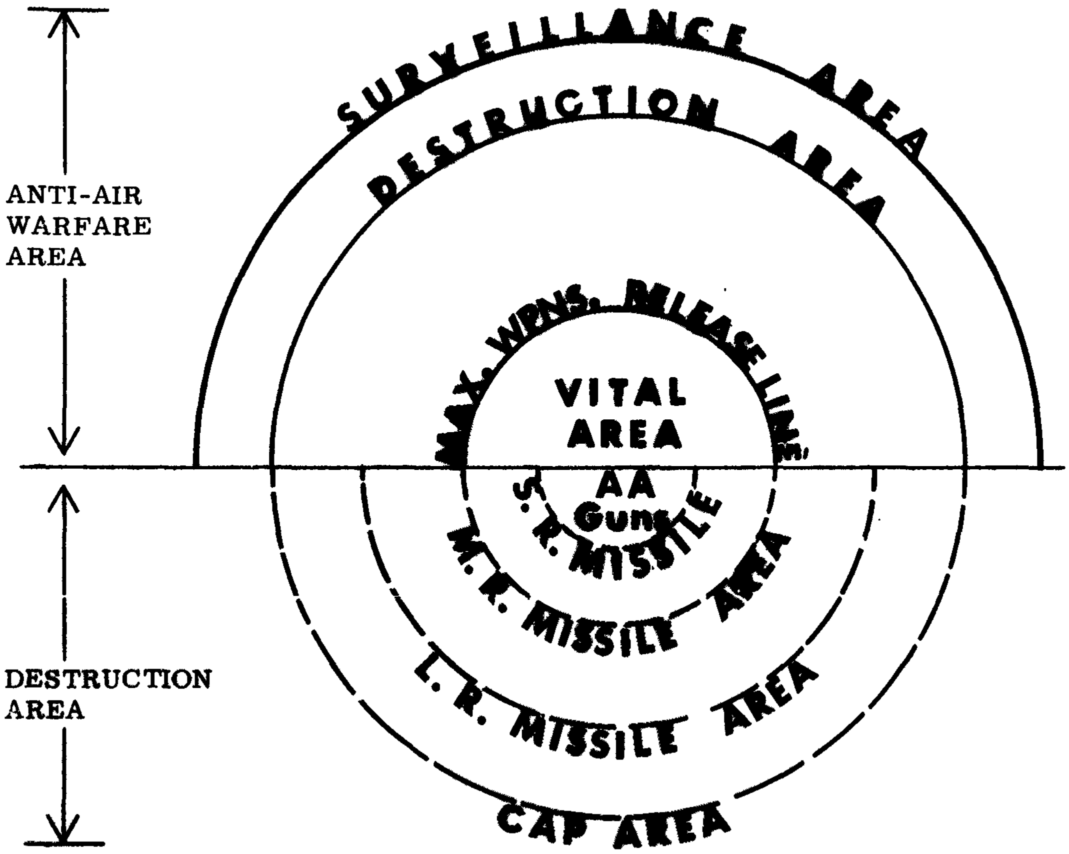
1. What is the nature of the "job"
2. Who is assigned the "job"
3. What is the "job" context.
4. How may the "job" performance be described.

Returning to the first category, I would like to discuss in somewhat more detail the terms listed under functional requirements. The first term listed is mission. Figure 1 shows an illustrative concept of an anti-air warfare area. Within a generically defined AAW mission context, at least two alternative strategies are possible. The objective of one strategy is to maximize the probability of avoiding detection and contact with enemy air units. The AAW effort is judged successful when the primary mission (e.g., strike, amphibious operation, etc.) is executed without the necessity of the force/ group having to engage enemy air units. The objective of the second strategy is to take those actions which maximize the probability of detecting and engaging enemy air units at the greatest feasible range from the vital area of the force. This second strategy appears to be the currently dominant strategy in AAW. Within the context of this second strategy, the overall criterion concept adopted for describing AAW performance during the engagement phase (described next) is response time, i.e., the time between initial detection and effective engagement of a threat. This criterion will be reintroduced later under the problem of selecting criteria with which to describe proficient performance.

Figure 2 graphically portrays and relates the next three terms listed under Category One; phases, functions and tasks. This figure is shown to illustrate three points. First, the notion of descriptive levels. At the broadest level, a mission description reflects the overall objective of AAW. At the next level, a mission may be divided into four sequential time phases, each described by a term denoting a major sub-objective of AAW. Associated with each mission phase there are functions, and the accomplishment of each

Figure 1

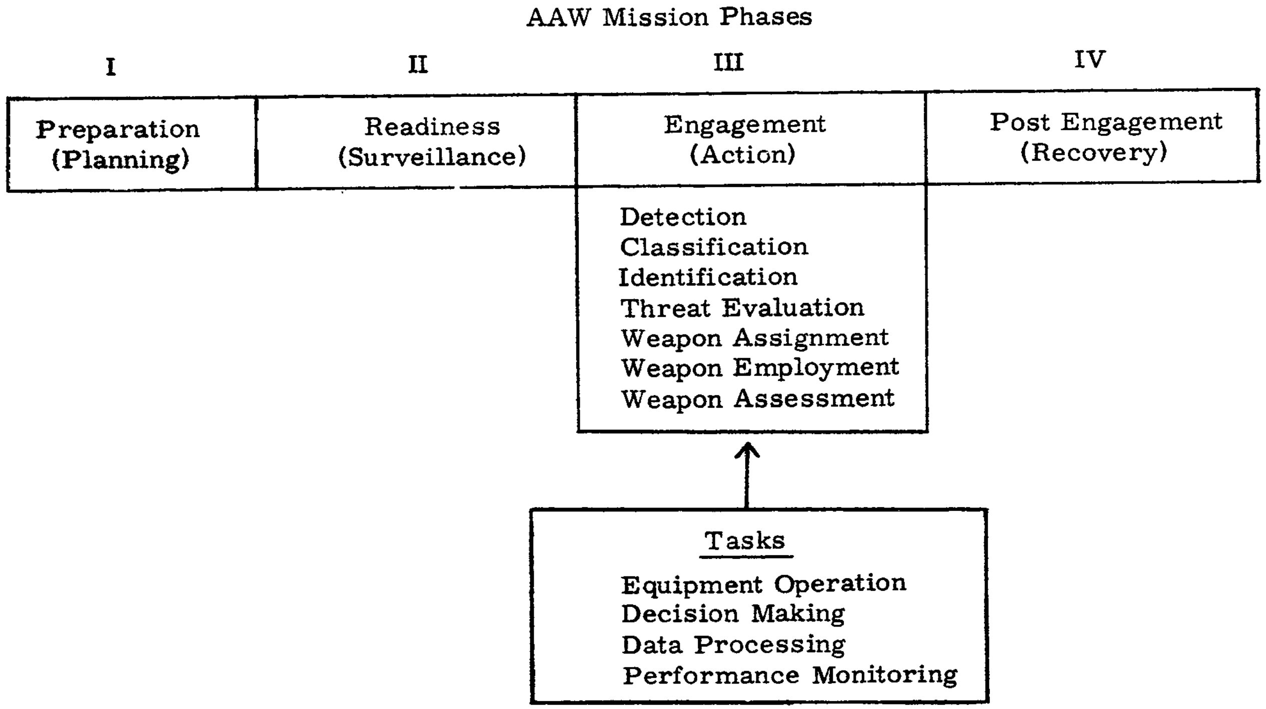
CONCEPT OF AN ANTI-AIR WARFARE AREA



L.R. = Long Range
M.R. = Medium Range
S.R. = Short Range

Figure 2

AAW Mission Phases with Functions and Tasks Identified for the Engagement Phase

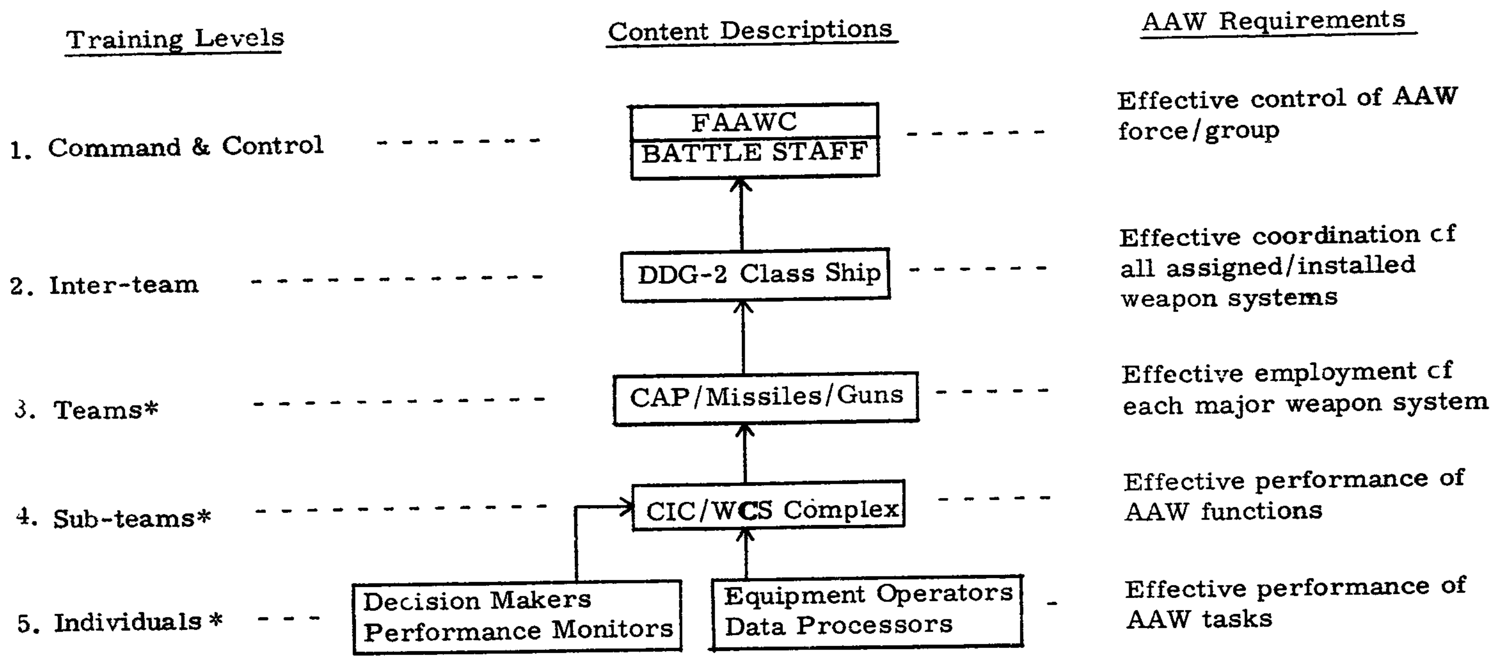


function involves, in some proportion and manner, the execution of various tasks. This notion of descriptive levels provides a convenient frame for identifying, investigating, and relating AAW performance requirements from the Force Anti-Air Warfare Commander level, assigned mission responsibility, to a specific individual assigned a particular task. Second, the notion of generality. The terms listed in Figure 2 are generic terms and can be used as guides for identifying, comparing and relating the performance requirements across different types and classes of AAW units. In other words, the functional classification scheme provides a generalizable frame on a "lateral" organizational basis as well as on a "vertical" command basis just mentioned. The third point refers to the use of this figure to indicate a major decision regarding study scope. Study effort was confined to those tasks and functions associated with the engagement phase of the AAW mission.

Figure 3 touches on the question of personnel "job" assignment, i.e., Category Two of Chart 1. Figure 3 illustrates two points. First, an attempt was made to classify and define personnel "job" assignments by combining a functional classification scheme (shown in Category One of Chart 1) with a structural orientation based on the more commonly used weapon system orientation. Personnel assignment levels are depicted in Column 1 of Figure 3. A structural classification is shown in Column 2, and a functional classification is shown in Column 3. Command and Control level refers to the Fleet Anti-Air-Warfare Commander and his assigned Battle Staff whose major responsibility is the control and allocation of all force weapon systems during the AAW engagement phase. Inter-team refers to a unit command level (in this case, DDG-2) whose responsibility it is to effectively coordinate the employment of all assigned/installed weapon systems during an AAW engagement. Teams are organized around the employment of specific weapon systems. Subteams are those in the CIC/WCS complex assigned to accomplish one or more of the functions required in an AAW engagement. Finally, individuals perform the specific tasks necessary to accomplish particular functions.

Figure 3

PERSONNEL TRAINING LEVELS IN AAW



* Within scope of present effort.

This personnel level notion will be further elaborated later in the presentation. Second, Figure 3 illustrates another aspect of the study scope. Research effort was confined to the DDG-2 class ship with major attention given to team, subteam and individual levels.

Referring back to Chart 1. Category Three identifies three types of contextual variables. The two classes of operational variables define the external requirements placed on an AAW system and its personnel. The AAW system must operate effectively within a specified environmental context in countering the threat described in terms of the characteristics of the raid. The two classes of variables assigned to the system encompass all of the hardware and software, and their operating characteristics associated with the system to which personnel are assigned. The design characteristics and capabilities of a system largely dictate the system's operating procedure. For this reason, operating procedures are included under the system heading. The two classes of variables assigned to the tactical heading deal with the system's objective (specific mission) and how the system's capabilities should be employed (doctrine) to most effectively counter a particular threat within a given environmental context. Figure 4 summarizes the context within which the study effort was conducted.

The last category shown on Chart 1 is concerned with the problem of performance criteria; the fourth but extremely important component in a behavioral specification. One of the problems generally faced in criterion development is the selection of criteria which are (1) logically related to some overall concept of effectiveness and (2) which are useful for comparing individuals for training or evaluation purposes. It is proposed in this study that level of proficiency of individuals, subteams and teams is one of the critical determinants for selecting appropriate criteria. Specifically, the use of diagnostic criteria is most appropriate during the formative learning or initial training stages. When the personnel involved have attained a sufficient

Figure 4

Context Variables

Context Variables	Scope
Raid Characteristics	Variation in raid parameters Simple situation, i.e., no jamming or deception tactics
Environmental Conditions	Limited variation in weather conditions
Shipboard Characteristics and Capabilities	DDG-2 Class Ship - Non-NTDS, All equipment assumed to be operating adequately
Derived System Operating Procedures	CIC/WC in GQ or Condition I State of Readiness
Assigned Mission and Doctrine	DDG-2 Class Ship on a picket station within context of dispersed Strike Force Utilization of available doctrine concepts

level of skill and knowledge proficiency then the use of a single overall criterion measure of effectivenss is meaningful. This would suggest that such measures as go/no-go, accuracy, time, completeness and quality are appropriate during the initial learning stages. When application of these criteria indicate that the personnel are consistently performing their specific tasks at a satisfactory level, the use of an overall measure of level of proficiency may be adopted. Standard operating procedures and equipment operating requirements may be used to provide the guidelines around which the basic skill and knowledge requirements are developed. Once these requirements are met, variation in procedure and technique may be appropriate for different situations and personnel. To provide for this, the criteria selected should be more of a "product" type of criteria rather than "process" type of criteria. The initial selection of an overall measure of operational effectiveness was guided by the criterion notion of response time mentioned earlier coupled with the concept of the AAW system as an information processing system. Within the scope of this study, the CIC/WCS complex of the DDG, like that of other units, receives inputs through the ship's sensors and communication links, processes these information inputs, and controls the ship's weapon and communication outputs in response to the mission and nature of the situation. Figure 5 illustrates this concept for a single unit. A combination of the "response time" concept and the information processing system concept suggested the use of "information processing rate" or amount of information processed per unit of time as the operational criterion by which to describe the performance of proficient individuals, subteams and teams.

As a final step preparatory to developing behavioral specifications, it was necessary to select key individuals and subteams from the CIC/WCS complex on which to concentrate attention. Four general considerations were used to guide the selection. Using Figure 6 as a graphic aid, the considerations are as follows:

Figure 5
A GRAPHIC ILLUSTRATION OF THE CIC/WC COMPLEX
AS AN INFORMATION PROCESSING SYSTEM

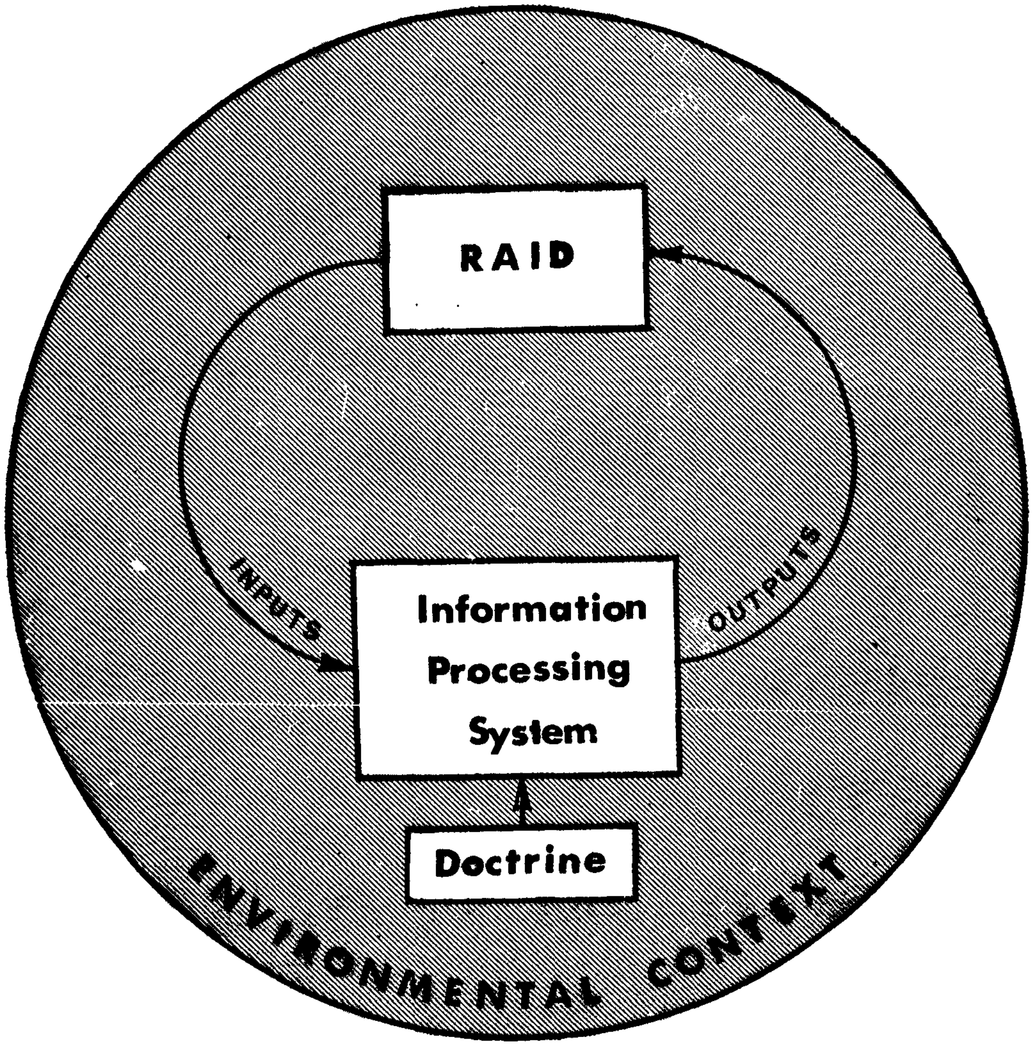
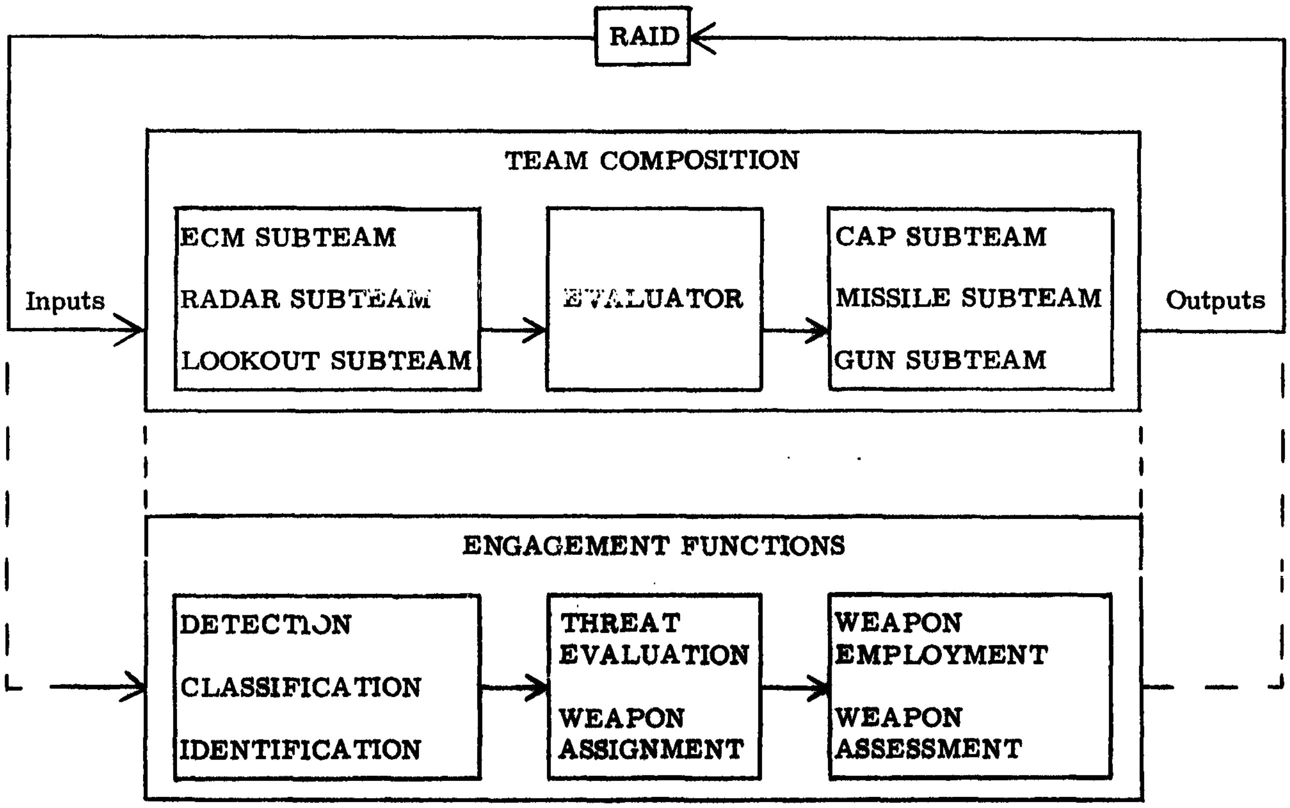


Figure 6

THE RELATIONSHIP BETWEEN TEAM COMPOSITION AND FUNCTIONS PERFORMED DURING AN AAW ENGAGEMENT PHASE



1. To promote representativeness, it was judged important to select individuals and subteams who perform different tactical functions dur.ng the engagement phase of an AAW mission.

2. To provide a broad skill and knowledge base, it was desirable to select individuals who perform tasks requiring qualitatively different skills and knowledges.

3. To provide realistic training requirements, it was essential to select personnel positions known to demonstrate a wide variance of proficiency among assigned personnel. It would be of little value from a training point of view to select individuals who show little difference in level of proficiency either as a function of equipment constraints or nature of the task required.

4. To meet operational considerations it was desirable to select individuals who perform critical tasks, i.e., tasks which significantly contribute to the operational effectiveness of the CIC/WCS complex during an AAW engagement.

Based on these considerations, the following individuals and subteams were selected.

1. ECM Subteam
2. Air Plotter
3. Evaluator
4. Air Intercept Controller
5. Missile Subteam

With respect to the first consideration, the ECM subteam performs detection, classification and identification functions. The evaluator is responsible for threat evaluation and weapon assignment functions, and the missile subteam performs the weapon employment and weapon assessment functions.

With respect to the second consideration, the air plotter's task is almost exclusively a data processing one; the evaluator's tasks are primarily decision making and performance monitoring and the AIC's tasks are a combination of the decision making, data processing and equipment operation. Note that all tasks listed earlier in Figure 2 are represented.

With respect to the third consideration, it was the judgment of experienced shipboard and school personnel that wide difference in proficiency existed among air plotters, evaluators and AICs.

With respect to the fourth consideration, the information processed by the air plotter is the primary information source for the evaluator, and is used by both the AIC and missile personnel during the initial stages of weapon employment. The evaluator is responsible for the overall performance of the CIC/WCS complex during an AAW engagement and makes decisions which determine which weapon and surveillance capabilities will be employed against what targets and when. The AIC functions as the major shipboard link in the employment of CAP, considered at the present time to be the principle operationally ready AAW weapon system.

The final topic of my presentation briefly covers the procedures used to investigate these selected individuals and subteams and what we might label as our initial findings. Figure 7 will be used as a guide in discussing procedures and results obtained for each selected individual and subteam.

Although no particular emphasis was given to the development of behavioral specifications for the entire CIC/WCS complex, we did construct, for other reasons, an information flow diagram and also performed a gross time line analysis for the entire CIC/WCS complex operating against an assumed single 600 knot bogey heading directly at the ship. Realistic detection, tracking, and weapon ranges for a DDG-2 were used in the analysis. The primary reason for mentioning this effort is to illustrate one approach for deriving behavioral specifications appropriate at the unit level. This procedure may be labelled

Figure 7

Source of Personnel Performance, Specifications

Personnel Levels	Primary Source for Obtaining Performance Specifications/Information
CIC/WCS Complex	Raid Characteristics (Outside - In)
Missile Subteam	Equipment Specifications (Inside - Out)
ECM Subteam	Training Standard
Air Plotter	Performance on Vertical Plot
AIC	Performance on a Training Simulator
Evaluator	Performance on Static Situational Tests

as the "outside-in" approach or the operational requirement approach. Given a particular set of raid parameters and assumed or realistic sensory, tracking and weapon capabilities, how much time is available for various weapon systems to respond to the threat. This provides a maximum time limit within which the system must respond to be effective against the threat. Using the gross time line analysis, the system has about 15 minutes from initial detection until the bogey is overhead. From initial detection until a CAP weapon system is normally ordered to break contact with the bogey (to facilitate acquisition and tracking by the missile system) there is about 8 to 8 1/2 minutes available. From the time that the missile system can acquire the bogey until the bogey is beyond missile firing limits, there is about 5 to 5 1/2 minutes available. This approach may be viewed as generating minimum acceptable behavioral specifications for any given raid situation.

An "inside-out" or system operating capability approach was used to provide an initial behavioral specification for the missile subteam. Manufacturers' specifications for the expected equipment performance were used initially as a base. Standard operating procedures written as part of individual ships doctrines modified upwards these initial estimates. Individuals with operational experience in the Tartar system were interviewed in addition to technical specialists in the schools. Finally, reports of the Operational Test and Evaluation Force were examined. Based on these sources, the resulting estimate of 56 seconds was derived as presenting the best available estimate of the response time capability of the missile subteam to process a single bogey through the system and to evaluate the results of the engagement at maximum missile range. It might be noted that altering equipment capabilities or SOPs can lenthen or shorten the time estimates. Using current estimates of equipment capabilities and current SOPs this figure represents about the shortest time that the missile subteam can completely process a bogey and evaluate the effectiveness of the weapon engagement at the maximum missile range.

The ECM subteam operating in a passive intercept situation represents still another method or procedure for arriving at a behavioral specification. A training instruction source was used as the basis for specifying an information processing rate which can be achieved by a proficient ECM subteam. The training situation described in this source is quite similar to the simple passive intercept situation investigated in this study. Our study indicates that an estimated 50 major data processing steps should be performed between initial detection to a DF fix and final evaluation (involving coordination among several ships), and the training document specifies that these steps should be accomplished within seven minutes or less to be judged as satisfactory. It should be noted that the situation under which the training exercise is conducted is in the Hampton Area (Norfolk) and presumably under nearly ideal conditions with the radiating source operating continuously or at frequent intervals.

An experimental effort was undertaken to develop a behavioral specification for the air plotter. The reported differences in level of performance expected from proficient air plotters served as one of the major reasons for conducting an experimental test. To accomplish this, it was decided to simulate a conventional CIC plotting situation in which plotters record the progress of an air exercise upon a vertical air summary plot, receiving their inputs from a radar operator and the RCO. An engagement was prepared during which as few as four and as many as twelve air targets each minute were reported to the plotter to be entered on his board. Ranges and bearings of these targets were tape recorded in the manner in which a radar search operator or radar tracker would relay this information during an actual raid. In addition, contact designation, composition, altitude, engagement by CAP or missiles and other amplifying information was added to the recording, as if given by the RCO. In order to make the presentation as normal as possible, the simulated radar targets, which consisted of bogeys and CAP, were advanced along reasonable flight paths and at conventional airspeeds. The test lasted nine minutes and nine air plotters with varying amounts of prior training and experience served as subjects. The results of the test showed that the proficient air plotter is capable of plotting accurate positions about 75% of the time when presented with 12 contacts per minute. A somewhat more unambiguous way of expressing this is in terms of information bits per minute. The proficient air plotter is capable of processing about 48 bits of information per minute assuming an average of 4 bits of information is required to completely describe a track with associated amplifying information.

An experimental investigation was also conducted with the AIC. Two forms of control are generally recognized: broadcast control and close control. In the former, the controller transmits information about bogey position, altitude and movements to the CAP pilot or RIO, who is responsible for planning his own intercept. Since this information need only be given at one minute intervals, the average controller can pursue up to six intercepts simultaneously. Close control, with conventional equipment and aids, usually involves controlling a single CAP at one time. The AIC must plan the intercept and provide the pilot with all changes of heading, altitude and airspeed. With the advent of the NTDS system, it is anticipated that the AIC will be able to close control more than one CAP at a time, and possibly for the very proficient controller, up to six CAPs simultaneously. Success in close control intercepts is currently defined by the rather stringent criterion that at the end of the run, the bogey be no more than 2.5 miles distant and within 20° of the CAP's heading.

One of the major reasons for running the experimental test was based on the anticipation that "time to intercept" would be a fairly sensitive criterion measure of proficiency and one logically related to the criterion concept of response time. However, with the eventual operational integration of NTDS, a possibly more useful measure of overall proficiency might be the number of CAPs that can be close controlled simultaneously.

The experimental test duplicated the actual intercept as closely as possible. Radar simulators of the AN/SPS-T2A type were used. Five different intercept situations were selected. Three AIC instructors and four less experienced AICs served as subjects. Unfortunately, the simulators were found to not run at constant enough speeds to make the measure of "time to intercept" meaningful. However, using the intercept success criterion mentioned above, the instructors did as well as or better than the students. For the present, the "success" criterion remains the primary measure of AIC proficiency with the current school requirement that 20 out of 20 successive intercepts meet this criterion standard in order for the AIC to be considered highly proficient.

The study effort devoted to the evaluator was in the nature of a pilot study. Since it was not possible to define standards of performance, when the evaluator's job has no standard definition, the pilot study examined those aspects of the evaluation process which conceivably may become performance standards. It's immediate objective was to identify some of the cognitive properties of the evaluator's job and to experimentally measure relationships between these properties in the conduct of a series of situational tests. An attempt was made to characterize the evaluator's utilization of various information inputs in relation to the time and quality of his decision outputs.

Four measures were obtained during the conduct of the situational tests.

1. Identification of Critical Inputs: The ability to recognize significant aspects of a raid on the basis of the limited information available in the displays (i.e., Air Tote, CAP Status, E/W Status, Weapons Assignment and Vertical Summary Plot). It involves an association between displayed information and knowledge of enemy capabilities and tactics.

2. Identification of Critical Own Forces Capabilities: Success along this dimension depends upon both an adequate grasp of the tactical situation and knowledge of one's own weapon status and capability. The capability for matching own equipment characteristics with opportunities to use the equipment demonstrates the extent to which the individual can effectively use the information he processes.

3. Quality of Command Decision: This decision is defined as the response to the experimental question, "What action would you take as the evaluator in the given situation?" Decision may include responses such as initiation of communications or change in disposition of forces or no immediate action. Quality of decision was defined on the basis of the expert judgment of CIC instructors.

4. Decision Time: The length of time from initial exposure of a situation display to the transmission of a decision by the subject was defined as decision time.

Ten synthetic tactical problems presented on slides were used in the pilot study. Eighteen officers on active duty participated in the study. These officers had received training in AAW evaluation, had experience as evaluators, or were in a position aboard ship in which they might be called upon to serve as evaluator, or possessed any combination of these qualifications.

The findings showed that the relationship between decision time and quality of decision was found to vary as a function of the situation. As situation complexity or deceptiveness increased, decision quality increased with the length of time used to arrive at the decision. In other so-called standard (less complex) situations, the faster the decision the better the quality.

The significant relationships between measures of critical inputs and decision quality, and critical own forces capabilities and decision quality indicates that the decision process involves two independe sources of variance whose combined variance accounts for almost two-thirds of the variance in the subjectively measured decision quality. Pending further study of the evaluator, these two decision process criteria may be used as intermediate criteria for estimating evaluators' job proficiency, or probably more useful as diagnostic measures of the knowledge and skills possessed or not possessed by the evaluator.

Present research effort is primarily aimed at a continuation and expansion of the exploratory work performed in the evaluator area.

PROCEDURES AND RESEARCH PLANNING FOR ANTIAIR WARFARE TRAINING PROGRAM*

Ed Weiss
The Matrix Corporation

METHODOLOGY

The rather broad scope of the study made evident the need for an approach which would describe the shortest possible route to the desired end products. Several techniques for describing the AAW man-machines system were considered. These included the use of equipment task analyses, operational sequence diagrams, and a technique developed and used by Matrix personnel referred to as the systems approach.

The systems approach was considered to offer several advantages over the other techniques. First and most importantly, the systems approach, unlike the other approaches, makes no demands in terms of the specificity of performance units. Since it is an iterative technique, the ultimate description which it provides is only as specific as it need be to achieve the end products. It can be seen that this approach is considerably different than the other techniques cited, since the latter require performance description at the task level, by definition. A description of the AAW system down to the task level of specificity is not considered feasible for this study. Secondly, the systems approach results in an integrated description, whereas the other techniques result in descriptions of discrete portions of the system (or subsystem) which ultimately must be conjoined if total system conceptualization is required. Third, the systems approach is not constrained in any way by specific equipment configurations, as is the case with other techniques. This is particularly advantageous in regard to this study because of the heterogeneity of equipments used within AAW, and, further, because of the changes in equipments which can be anticipated in the near future.

*The material used in this presentation was taken from the following reference.
The Matrix Corporation. Procedures and Research Planning for Antiair Warfare Training Program: An Interim Report. Arlington, Va.: The Matrix Corporation, 22 November 1963. (Contract No. N61339-1445, Project No. 7596-1) CONFIDENTIAL

The essence of the systems approach utilized for this study is a basic requirements orientation. In brief, it is predicated on these assumptions: any arrangement of men and machines must provide for the accomplishment of certain functions; and, in order to demonstrate satisfaction of this requirement, all performances by either man or machine must be couched in concrete, measurable terms. Such criteria constitute not only objective definitions of system performance but also realistic behavior goals for training.

Plan of Work

The foregoing systems approach was applied in the generation of the work plan for this project as shown in Figure 1. The requirements or functional orientation (rather than a means orientation) is indicated by the fact that, while all successive input-output states in the diagram are defined, the means by which the various input-output transductions are accomplished are not specified but merely implied. The arrows shown in the diagram indicate the performance requirements in terms of the various input-output relationships. A box locates the point at which a transduction is required to translate a given input state of affairs into the required output. The circles on the diagram depict those points at which the system is provided with readouts or meters for the purposes of performance assessment and troubleshooting. In this particular case they represent reviews with the contract technical monitor and the AAW training research team. Each such circle implies a feedback line for retrofit of the project as appropriate, although these lines are not indicated on the diagram.

Figure 1 diagrams the worksteps required for the study as follows: analysis of the AAW system (Boxes 1, 2, and 3 in the figure), description of the means whereby AAW training is current accomplished (Box 4), review of those aspects of training research corresponding to the human performances exhibited in the system (Box 5), and the generation of the long range research and shorter range developmental end products previously described (Boxes 6 and 7).

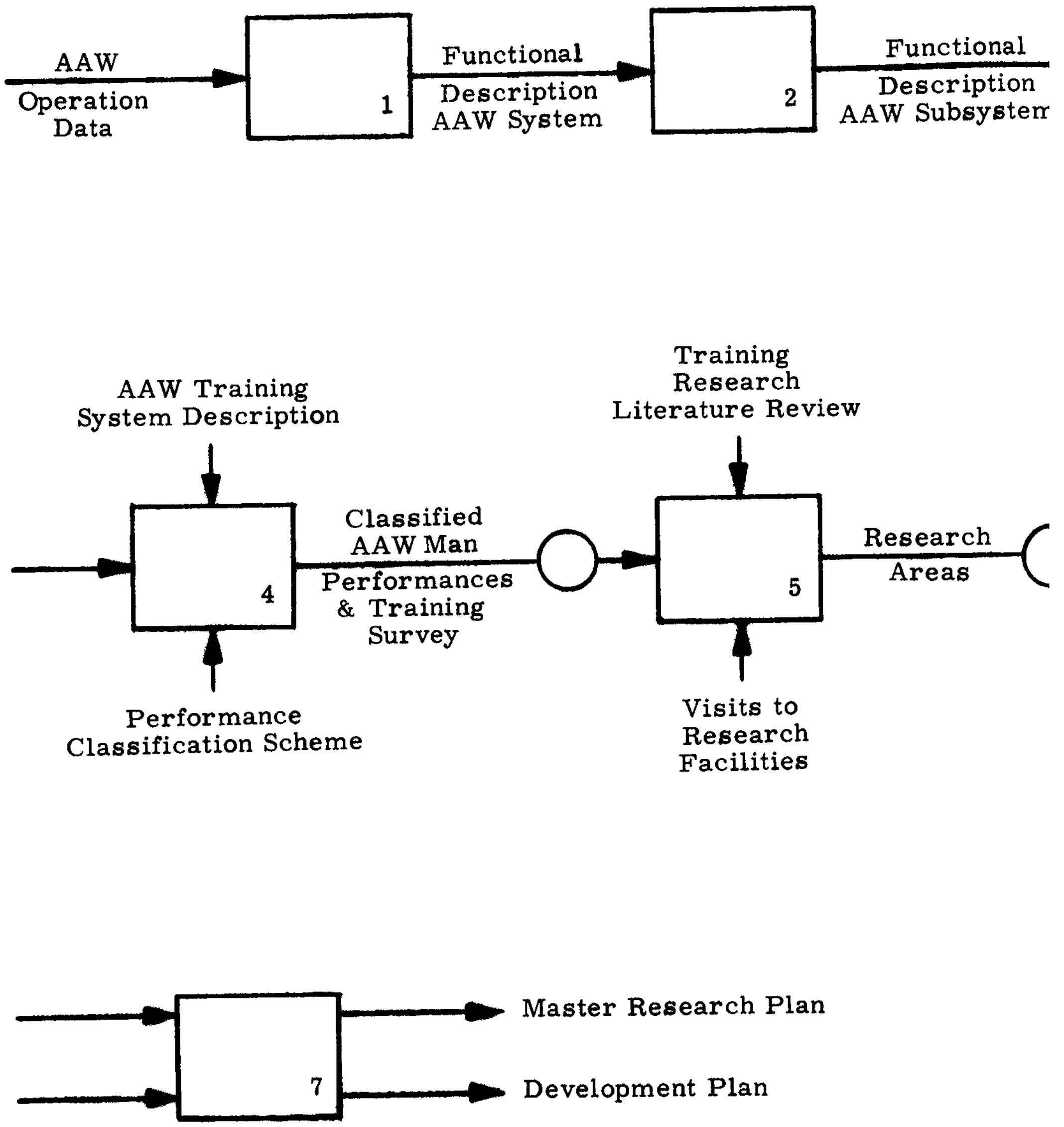


Figure 1 Plan o

CONFIDENTIAL

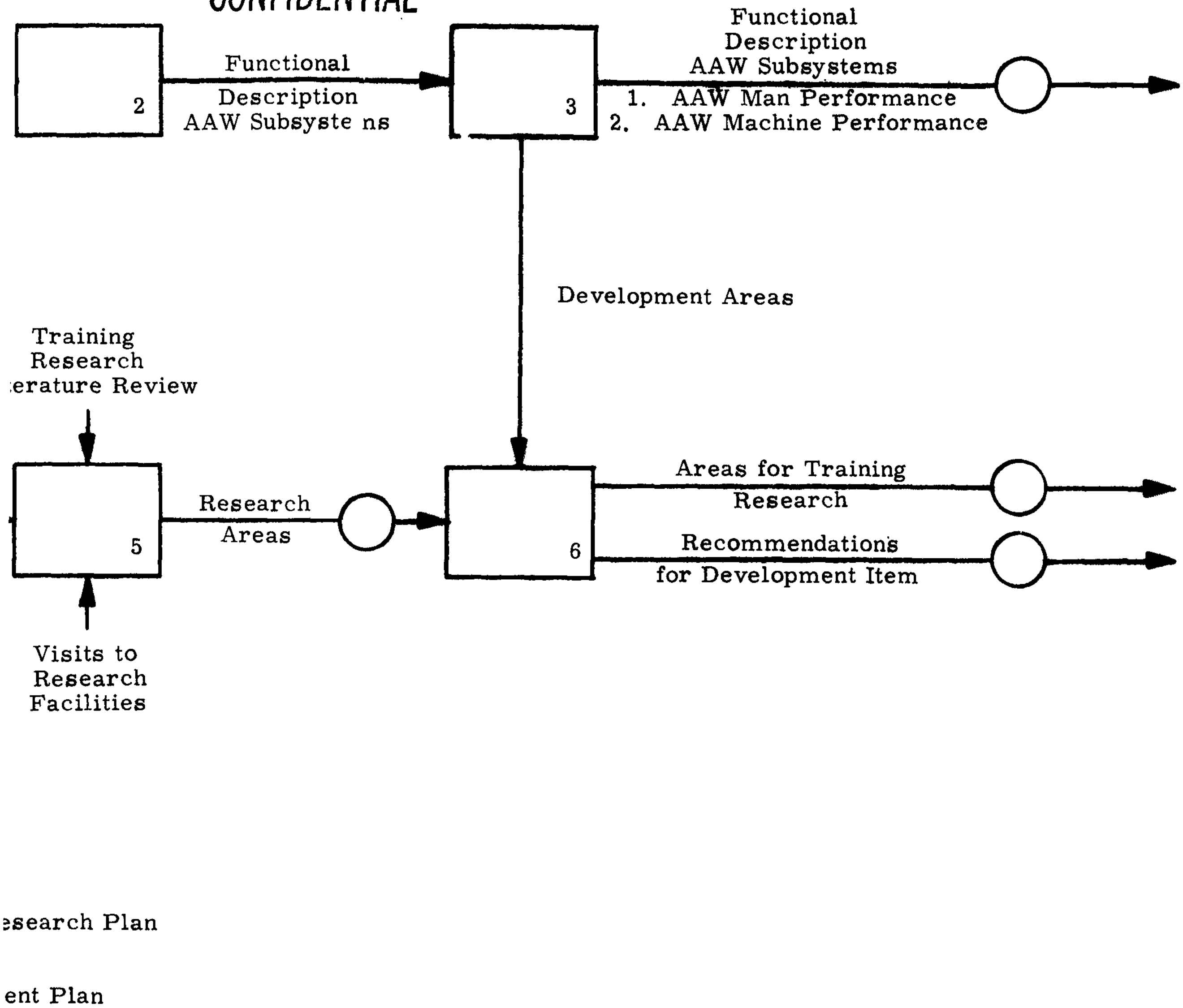


Figure 1 Plan of Work

CONFIDENTIAL

Use of Information Flow Model

Previous research (3) has indicated that the functions necessary to the AAW system are: surveillance, detection, classification, identification, threat evaluation, weapons assignment, weapons employment, and kill assessment. These functions constitute the basis for analysis of the AAW system in this project.

The primary functions of AAW are equivalent to the functions performed in the CIC area, namely: the gathering, display, assessment, and dissemination of information (24). Although the means employed for the accomplishment of these functions, and the procedures established for utilization of these means may vary widely both within and across ship types (30, 31, 32, 33), the essential system characteristic, an information processing effort, is manifest. It appears, therefore, that the most suitable model for describing the AAW system is an information flow model. Such a model offers several major advantages. First, it spotlights the nature of the tactical data flow which is the essence of AAW. Second, it provides a criterion for excluding behaviors which are necessary to AAW but which in terms of training can best be assigned to other areas, such as ship maneuvering, pilot performance, etc. Third, all positions which are made explicit by the tactical data flow model will only be defined in terms of AAW performances. Thus, the evaluator is described in terms of the decisions which he makes and other behaviors which he may evoke, in regard to AAW only. It should be noted that this provides a sharp demarcation from other systems similarly described such that the various interfaces can be easily established. For example, an important finding might derive from the fact that because of the importance of interaction effects, higher echelon decision making behaviors for AAW and ASW should be trained simultaneously.

The next section of this report describes the work accomplished to date,

WORK ACCOMPLISHED

The project is in its early stages. The primary focus of the effort to date has been in the area of system description (Boxes 1, 2, and 3 of Figure 1). The paragraphs that follow summarize the work accomplished thus far in this area.

AAW System Description

The section on methodology stated that the AAW system delimited to key areas and viewed as an information processing system, would be described in a particular diagrammatic form. The material on which this description is based includes NWP's and NWIP's (23, 24, 25), earlier research and descriptive efforts (3, 22, 27, 29), current ship CIC procedures (30, 31, 32, 33), and fleet operations orders (1), and observation of simulators at Naval training facilities as well as interviews with Naval personnel. To date, sufficient information has become available to generate preliminary descriptions of the conventional CIC (Figure 2), the CAP subsystem (Figure 3), the missile subsystem (Figure 4), and the passive EW subsystem (Figure 5). Further information-gathering efforts are required for the generation of materials on NTDS, and on the gunnery subsystem, as well as for validation and completion of the diagrams shown in the Figures.

The diagrams shown are felt to be useful in themselves as products for the following reasons:

1. They define and delimit the AAW system.
2. They allow for an analysis of the primary functions required by the system regardless of the ship type, manning levels, or onboard equipments.
3. They show the interactions which exist among these functions.
4. They allow for the derivation of human performances in meaningful system terms.

5. They assist in the generation of appropriate criteria for training development and evaluation.

6. They permit a ready establishment of the interfaces with other systems such as ASW.

7. They provide a source of documentation for future work efforts.

The diagrams under discussion illustrate pictorially the operator positions considered to be key AAW jobs.[1] It was felt that another way to consider these positions might be in terms of numbers of incumbents, since this would allow judgments to be made on such topics as cost versus criticality versus impact for a given research area. Table I shows, for combatant vessels only, the Condition I numbers of incumbents in AAW. It can be seen that the system is extensive in terms of operators.[2]

AAW Training Description

An effort directed at description of current AAW training (Box 4 of Figure 1) has begun. The effort includes the locations at which training is administered, the type of training involved (team or individual), and the training techniques used (lecture, simulator). Table II summarizes results to date in this effort. The chief sources of data for the table consist of interviews with on-site instructor personnel and BuPers representatives, reviews of curricula lesson guides, lesson plans, and handout material currently in use (4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17), plus observations by the researchers of training in progress.

[1] For another discussion of key AAW positions, see (3). (9) contains handout materials describing a typical cruiser-type CIC operation, and commenting on the contribution of each operator position.

[2] From discussions with BuPers representatives, August 1963.

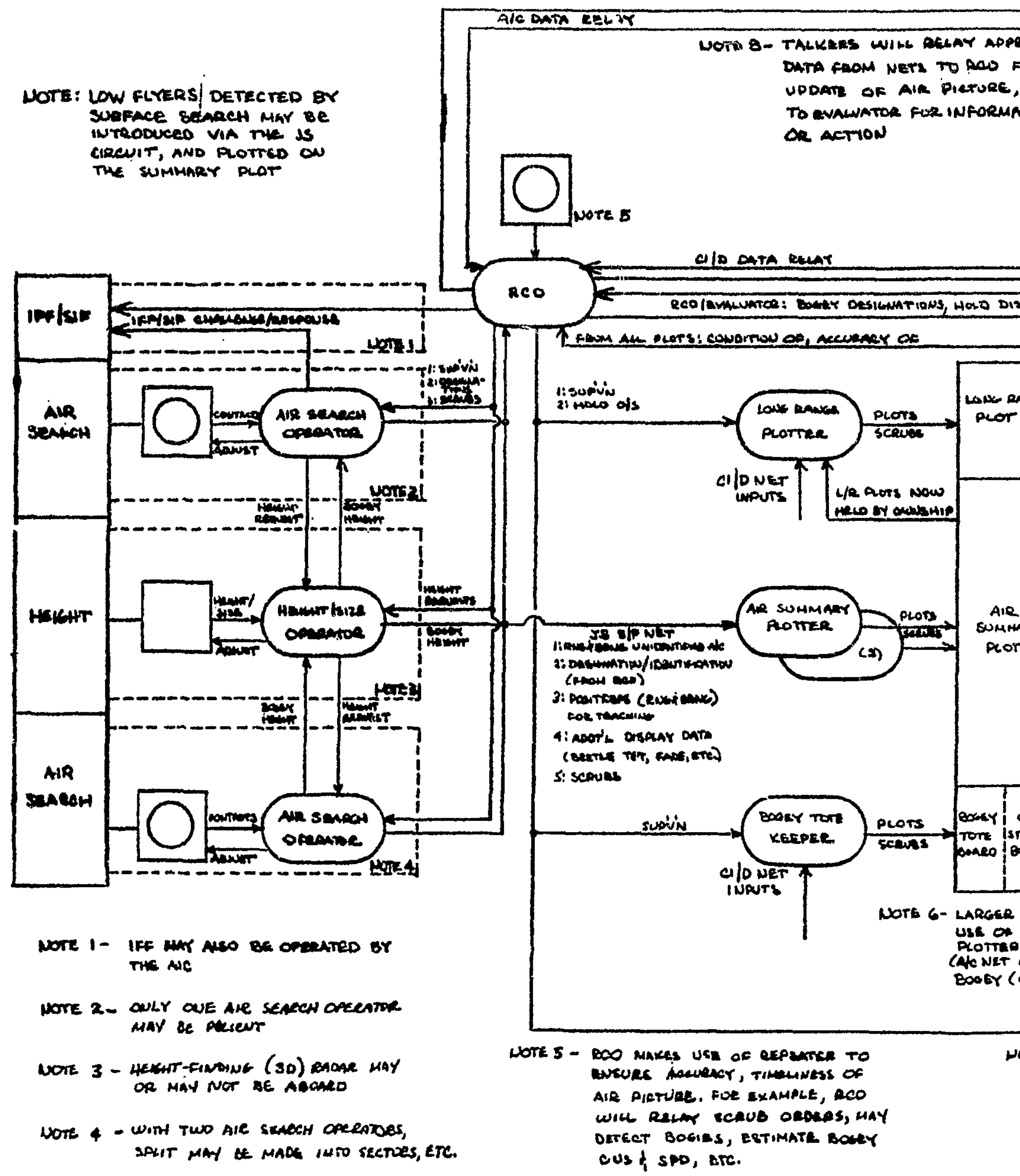


Figure 2 Conventiona

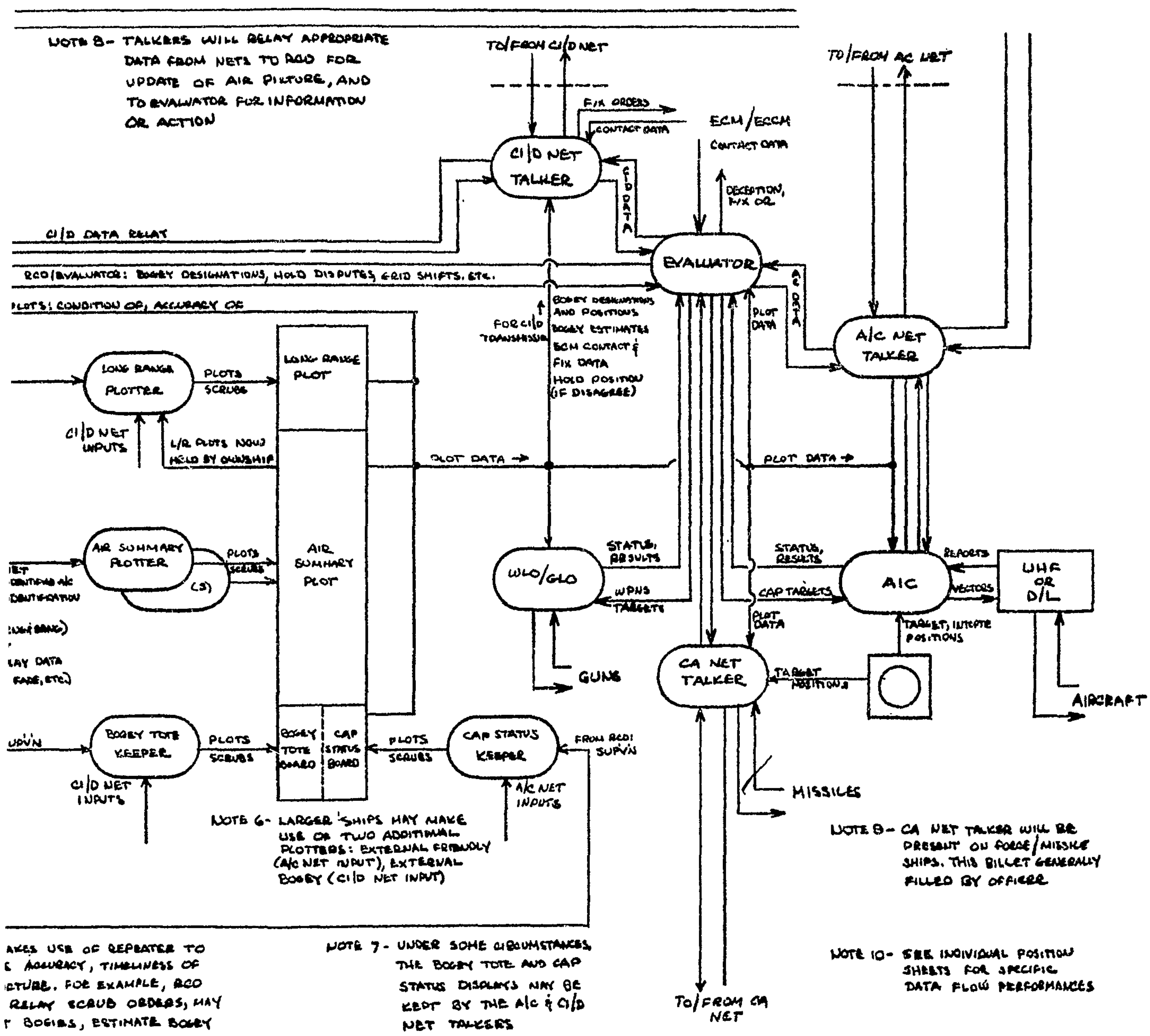


Figure 2 Conventional CIC (Preliminary)

2

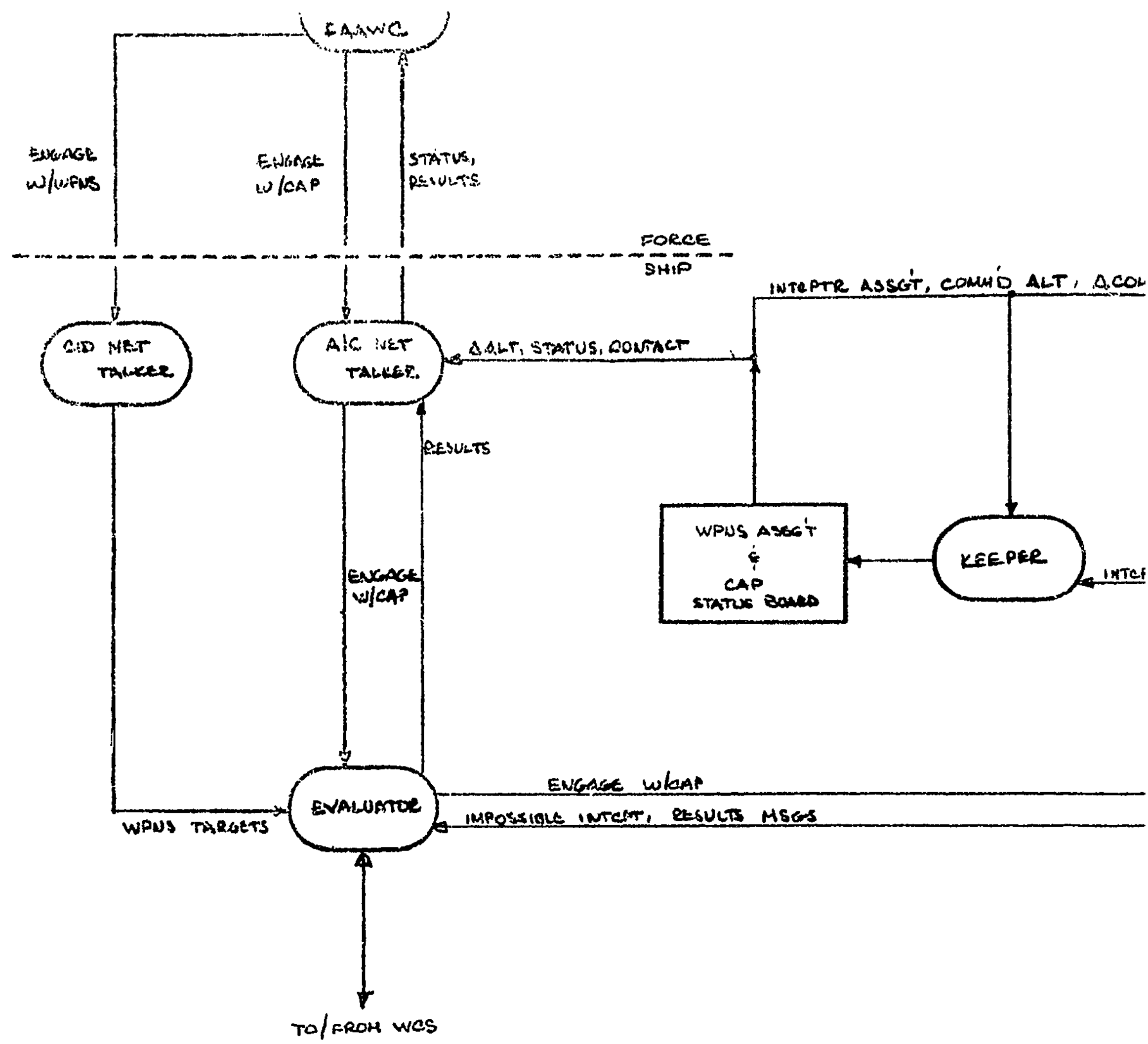


Figure 3 CAP Subsy

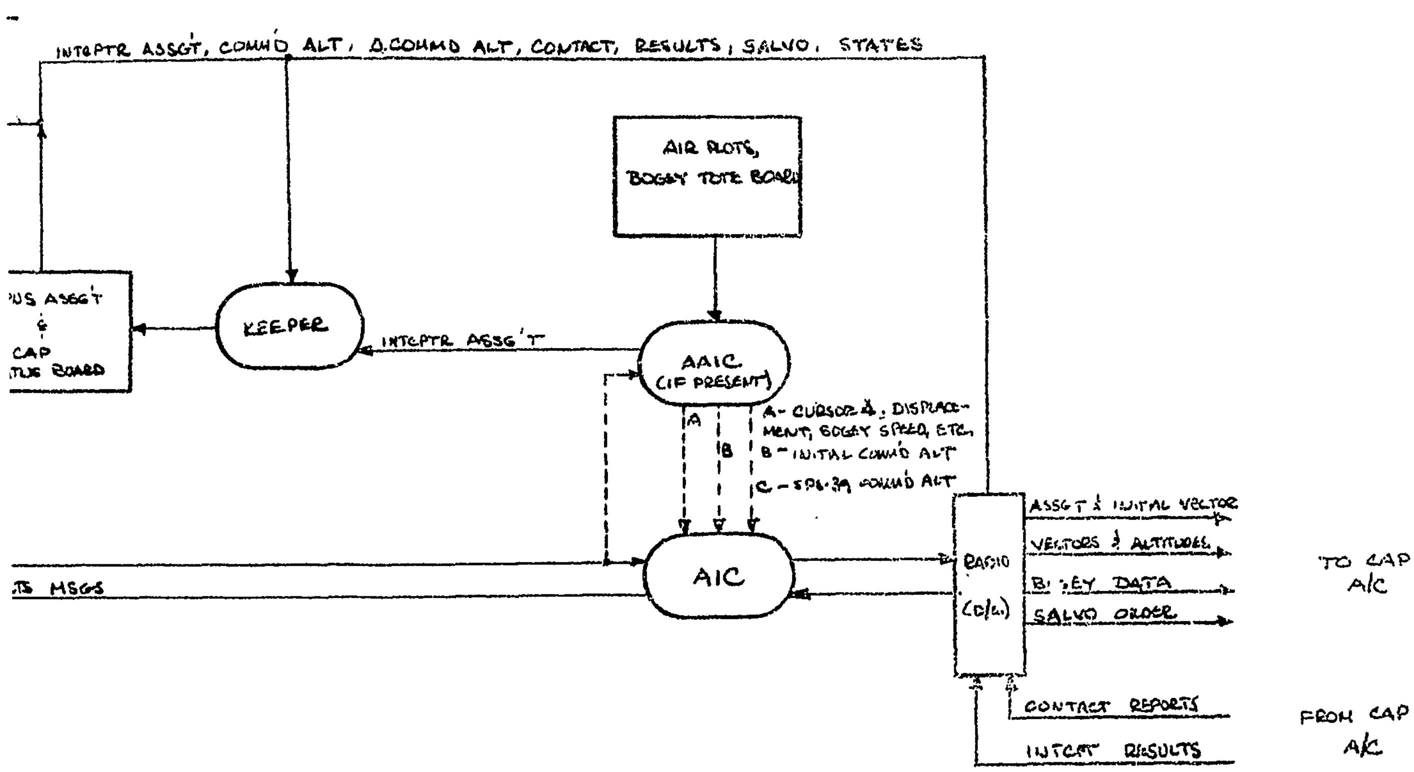


Figure 3 CAP Subsytem (Preliminary)

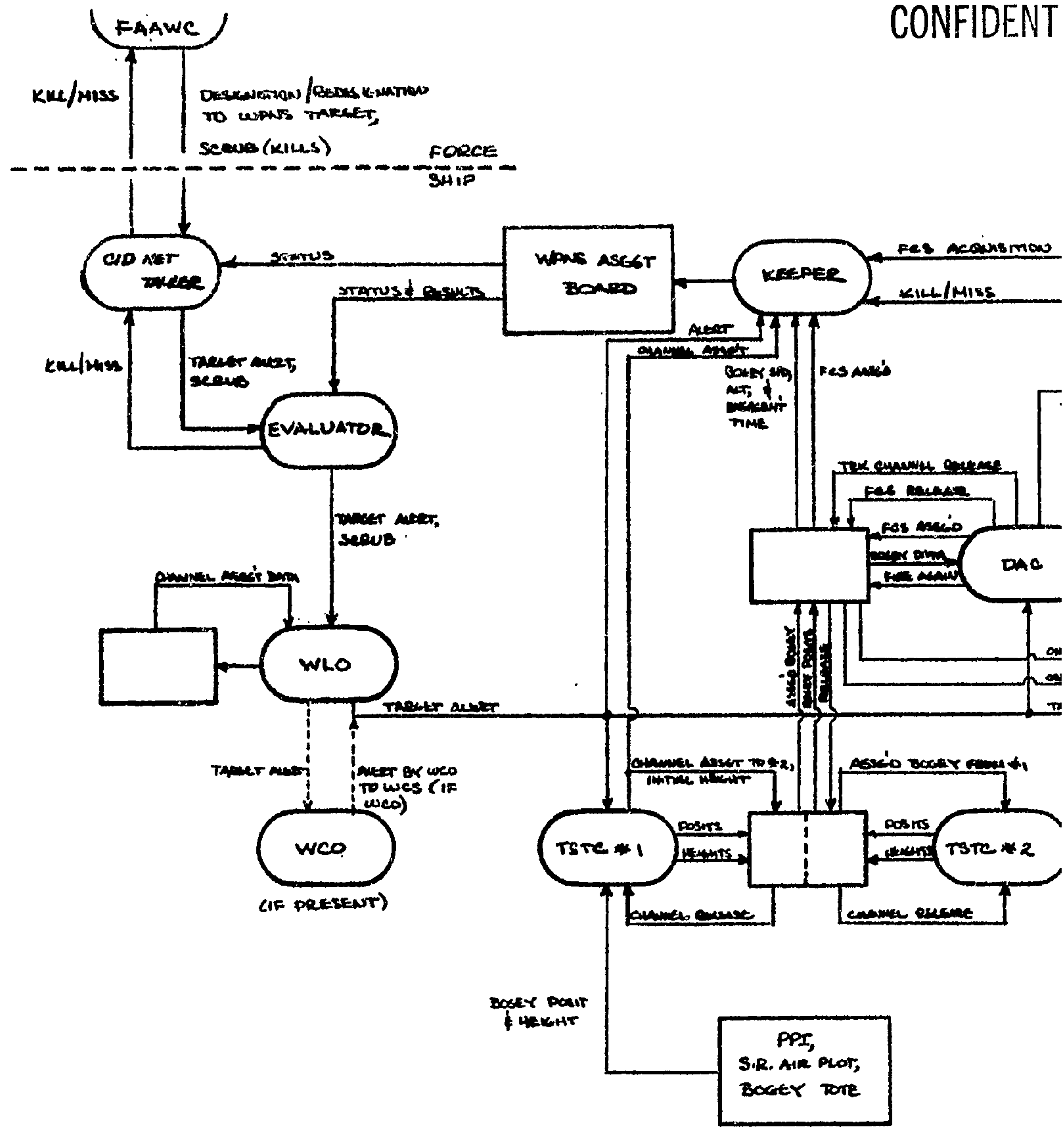


Figure 4 Missile Su

CONFIDENT

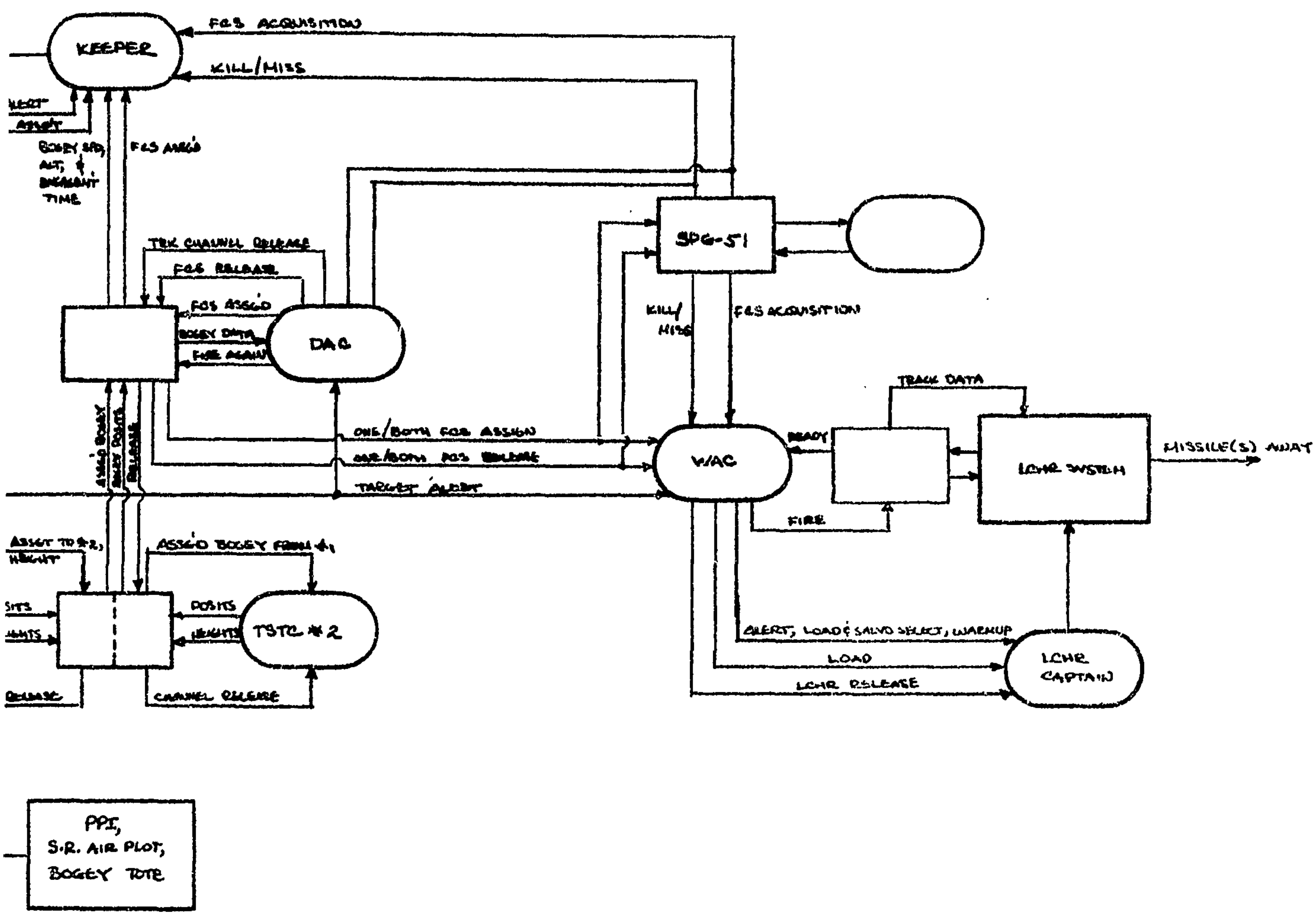


Figure 4 Missile Subsystem (Preliminary)

2

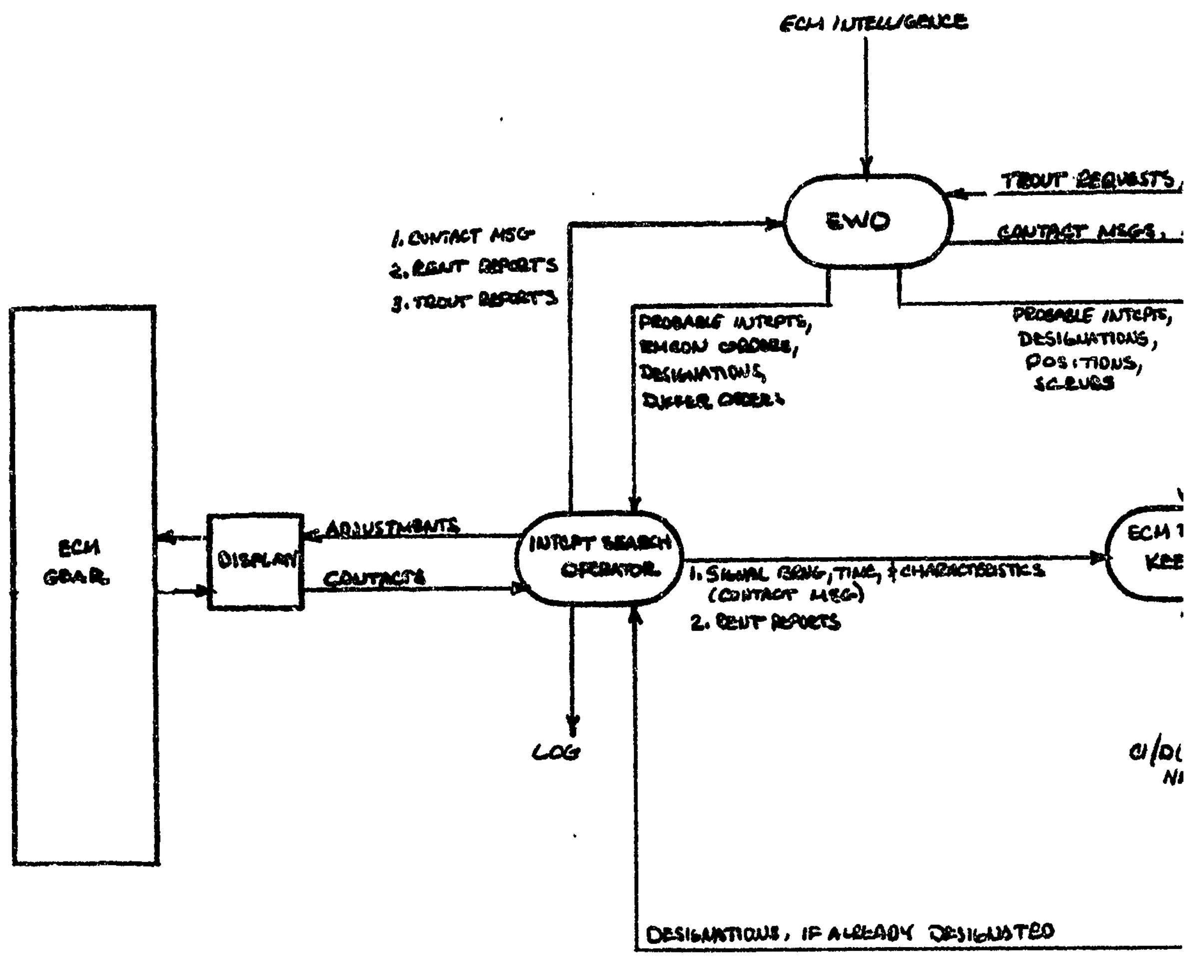


Figure 5 EW Subsy

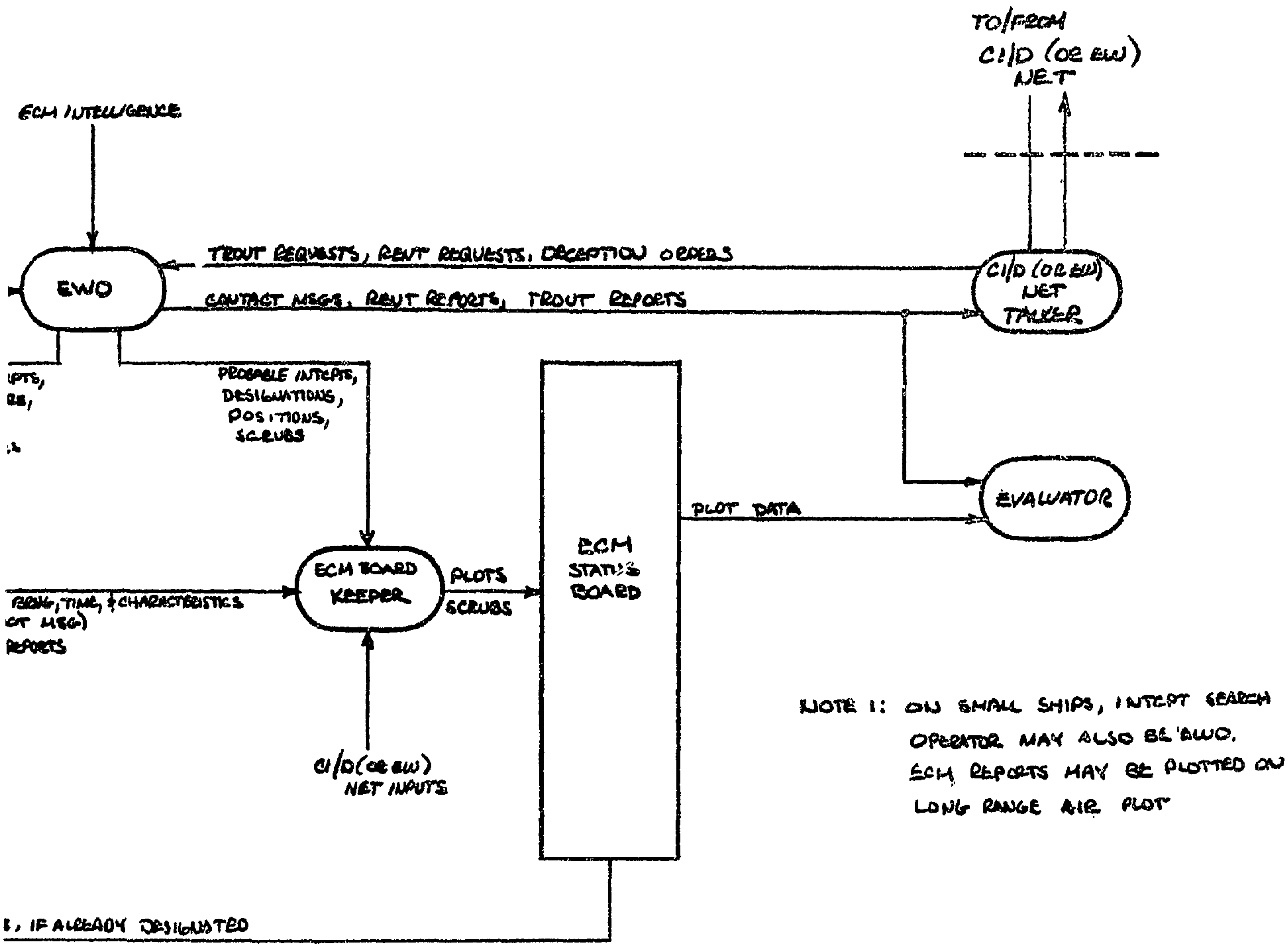


Figure 5 EW Subsystem (Preliminary)

2

TABLE I

DISTRIBUTION OF AAW POSITIONS BY SHIP TYPE

Battle Duty	Carriers (W/SAM)	Carriers (WO/SAM)	Cruisers (W/SAM)	Cruisers (WO/SAM)	Destroyers (W/SAM)	Destroyers (WO/SAM)	Totals
Evaluator (+ Asst.)	2	2	2	2	1	1	379
RCO (+ Asst.)	2	2	2	2	1	1	379
WLO	1	0	2	0	1	0	105
GLO	0	1	2	2	1	1	348
EWO	1	1	2	2	1	0	132
AIC	4	4	4	4	1	1	461
WCO	1	0	2	0	1	0	105
DAC	1	0	2	0	1	0	105
WAC	1	0	2	0	1	0	105
							2119
Detector	2	2	2	2	1	1	379
Tracker	2	2	2	2	1	0	159
Height/Size	2	2	2	2	1	0	159
ID	2	2	2	2	0	0	82
Intercept Search	2	2	2	2	1	1	379
Jammer	2	2	2	2	1	1	379
CID Net TLKR	1	1	1	1	1	1	338
AC Net TLKR	1	1	1	1	1	1	338
VP Plot 1	2	2	2	2	1	1	379
VP Plot 2	2	2	2	2	1	1	379
Tote Board	2	2	1	1	1	1	365
CA Net TLKR	0	0	2	2	0	0	28
TSTC 1	2	0	2	0	1	0	109
TSTC 2	2	0	2	0	1	0	109
	37	30	45	33	21	12	3582
Number of Ships	4	23	12	2	77	220	
	148	690	540	66	1617	2640	5701

TABLE II

CATEGORIES OF BEHAVIOR AND TRAINING RECEIVED BY AIR SEARCH OPERATOR*

Behavioral Categories	Individual Training	Team Training
I. Data Collection A. Identification 1. Actuates proper switching on console to give appropriate display B. Perceptual Discrimination 1. Recognizes target return on PPI	Class A School - 24 weeks School is generally considered preparation for RD3 or RD2. Training includes techniques in surface and air plotting, use of countermeasures equipment, sound-powered and R/T procedures. Preventive maintenance at a basic level is taught.	RS-12 or RS-14 Device Provides an opportunity primarily for practicing air search operator function within conventional CIC team context. *** Training evaluation is performed informally primarily as post-problem critiques.
C. Principles and Relationships 1. Realizes improper settings on PPI may damage CRT screen D. Procedural Sequences 1. Activates check-out equipment	Class B School - 36 weeks School is generally considered preparation for RD1 and RDC. Training includes mathematics, physics, and advanced CIC procedures. Advanced maintenance and repair of equipment is taught.	On-The-Job Training and Exercises No satisfactory training data at this time.
E. None F. Perceptual Motor Acts 1. Positions cursor strobe on target return	Class C School** This is primarily maintenance training and is oriented toward a single system.	
II. Message Formulation D. Procedural Sequences 1. Aware of proper sequence in reporting bogeys	On-The-Job Training No satisfactory training data at this time.	
III. Message Transmission D. Procedural Sequences 1. Reports bogeys in proper sequence, citing appropriate data		

*It is assumed that the Air Search Operator will have a Radarman's Rate

**Depending on incumbent's rank, he may have attended any, all, or none of these schools

***Within the flexibility of the device, a CIC structure similar to that aboard ship is provided.

Behavioral Classification Scheme

A scheme for classifying in behavioral context the performances taught in AAW training, and required for operation of the AAW system, is required as an entry point to the literature of training research. Various classification schemes were considered for this purpose and it was finally decided to utilize the one proposed by Lumsdaine (21) which was cited and modified by Parker and Downs (26). The following version is suitable for present purposes:

1. Learning Identifications. This category refers to identifying objects in terms of their appropriate nomenclature, locating and relating them functionally. It includes the acquisition of factual knowledge.

   Example: Identifying the various controls associated with a PPI display.

2. Learning Perceptual Discriminations. This category involves the integration of the various sensory inputs to provide for meaningful resolution.

   Example: Discrimination of a signal on a PPI display.

3. Understanding Principles and Relationships. This category refers to the essence of the valid reasoning process as demonstrated by the ability to state, illustrate, and recognize the implications of a relationship and the underlying principles on which it is based.

   Example: A knowledge of the principles underlying digital devices.

4. Learning Procedural Sequences. This category refers to carrying out operational sequences which may relate to hardware, tactics, the more mechanical mathematical manipulations, etc.

   Example: Voice communications procedures or equipment activation procedures.

5. Making Decisions (Choosing Courses of Action). This category involves deciding upon appropriate course(s) of action for a complex situation where proceduralized alternatives are not available. It can, however, also include the selection of the most satisfactory procedural sequence as well as the critical temporal decision of when to respond.

   Example: Selection of the appropriate counter-threat system.

6. Performing Skilled Perceptual Motor Acts. This category refers to the integration of "discrete" responses into smoothed "continuous" outputs. Frequently, several simple skills may have to be integrated themselves to form a more complex skill.

   Example: Writing backwards to display information from the rear of a plot board.

The foregoing classification scheme with appropriate elaboration for specific performance categories appears to provide a convenient technique for interrogating the literature and other sources in order to derive long range research hypotheses. However, it does not provide a satisfactory link to the information flow models used to describe the AAW system. In order to account for this discrepancy, it was decided to superimpose another classification which would group the behavioral categories in information flow terms. Since the items in this classification are self-explanatory, they are presented below without further elaboration:

1. Data Collection
2. Message Formulation
3. Message Transmission
4. Information Storage
5. Information Retrieval

6. Data Processing

7. Mode Select (Distinguishes decision-making outputs from proceduralized responses.)

8. System Responses

Table II presents an example of the application of this classification scheme for one position—the Air Search Operator. This table is required as the output of Box 4 in Figure 1. It will be completed for the other AAW battle duty stations as part of the future work effort.

The data presented in Table II reflect the fact that present training as conducted by BuPers schools is oriented toward Rates rather than functions.[1] In the case of the Air Search Operator, the incumbent will have attended the Class A or B schools specified only if he has a Radarman Rate.

The comprehensive list of battle duty stations which will be covered for the conventional CIC is shown below. A similar list will be generated for NTDS equipped ships.

Air Search Operator
*Tracker
*Height/Size Operator
Long Range Plotter
Air Summary Plotter
*Bogey Tote Keeper
*CAP Status Board Keeper
CID Net Talker
RCO
AC Net Talker
AIC/AAIC/AIC(S)
**CA Net Talker
*GLO
**WLO
**TSTC Operator
**DAC Operator
**WAC Operator
**WCO
Intercept Search Operator
*ECM Board Keeper
*Jammer Operator
ECM Officer/EWO
Evaluator

*Position not manned if function performed by other team member.
**Position manned if SAM Ship.

[1]From interviews with BuPers representatives, November 1963.

BIBLIOGRAPHY

1. AAW Annex (U) to COMSIXTHFLT, Operation Order 1-62 (C)

2. Bavelas, A. Communication pattern in task oriented groups. J. Acoustical Society of America, 1950, 22, 725-730 (U)

3. Behavioral Specifications for Key AAW Personnel and Subteams in the CIC/WCS Complex, HSR-RR-63/16-Sd, Jul 63 (C)

4. Commander Training Command, U. S. Atlantic Fleet Instruction P1540.IL, Catalog of Courses Available at Atlantic Fleet Shore Based Training Activities, 5 Feb 63 (U)

5. COMTRALANTINST 1550.IE, Development and Processing of Curricula Within the Training Command, U. S. Atlantic Fleet, 20 May 63 (U)

6. COMTRAPACINST P1500.2M CH-6. Index and Convening Dates for Courses Available at Fleet Anti-Air Warfare Training Center, San Diego (U)

7. COMTRAPAC Instruction P1500.2M, U. S. Pacific Fleet Training Digest, 22 Sept 60, with changes (U)

8. Curriculum for Course No. 306, CIC Procedures, Rev. 1 Apr 63 (C)

9. Curriculum for Course No. 313, Evaluators Course, Rev. 20 Nov 62, incl. Master Schedule, Lesson Plans, Assignment Sheets (C)

10. Curriculum for Course No. 314, CIC Officers' Course, Rev. 20 Oct 62 (C)

11. Curriculum for Course No. 318, Electronic Warfare Officers' Course, 20 Aug 62 (C)

12. Curriculum for Course No. 319, Intermediate Air Intercept Control, Rev. 7 Nov 62 (C)

13. Curriculum for Course No. 320, Air Intercept Controller Supervisor, Rev. 13 Nov. 62 (C)

14. Curriculum for Course No. 350, PCO/PXO CIC and Anti-Air Warfare Course, Rev. 15 May 63 (C)

15. Curriculum for Course No. 373A, Advanced Anti-Air Warfare Team Training, Rev. 20 Nov 62 (C)

16. Curriculum for Course No. 373B, Basic Anti-Air Warfare Team Training, Rev. 20 Nov 62 (C)

17. Curriculum for Course No. 374, Operational Staff Officers, Anti-Air Warfare Course, Rev. 20 June 62 (C)

18. Festinger L. Architecture and Group Membership, J. Soc. Issues, 1951, 7, 152-163 (U)

19. Green, N E. Fatigue and Tension in SAGE Operator Team Performance: A Sociological Analysis. Operational Applications Office, Air Force Command and Control Development Division, TN-60-15, Bedford, Mass., May 1960 (U)

20. Leavitt, H. J. and Mueller, R. A. Some Effects of Feedback on Communication, Human Relations, 1951, 4, 401-410 (U)

21. Lumsdaine, Arthur A. Design of Training Aids and Devices. In John D. Folley (Ed.) Human Factors Methods for System Design, AIR, 1960 Project No. AIR-290-60-FR-225 (U)

22. NTDS Service Test Instrumentation Vol. I, DLG-10, DLG-11, 18 May 59 (C)

23. NWP 32(A) Combat Information Center (C)

24. NWIP 31-3(A) CIC Air Control (C)

25. NWP 32(A) Anti-Air Warfare (C)

26. Parker, J. F., Jr. and Downs, J. Selection of Training Media, ASD Technical Report 61-473, Sept 61 (U)

27. Performance Standards for Anti-Air Warfare, FAAWTC, Pt. Loma, 14 Jan 63 (C)

28. Shaw, M. E. Some Effects on Unequal Distribution of Information Upon Group Performance in Various Communication Nets. J. Abnorm. Soc. Psychol., 1954, 49, 547-553 (U)

29. Symposium on AAW Training Held by CINCLANTFLT (C)

30. USS Bainbridge Inst. 03000.1 CIC Doctrine (C)

31. USS Dewey Inst. 05400.1A CIC Doctrine (C)

32. USS Dewey Inst. 05400.5 Anti-Air Warfare Doctrine (C)

33. USS Forr. Inst. 03560.1A CIC Doctrine (C)

COORDINATION REQUIREMENTS FOR THE AAW

TRAINING RESEARCH PLAN

John A. Nagay

As has been pointed out earlier, four alternative approaches are available to research planners attempting a research attack on some broad operational training front, like AAW or ASW. They are: (1) a monolithic contract structure, as exemplified by the RAND Corporation, (2) a monolithic in-service or combination of in-service and contract structure headed by a program manager, (3) a laissez-faire approach in which the independent, unintegrated, discrete research efforts that exist today are left to go their separate ways, and (4) a kind of "team-of-professionals" approach which includes some of the features of the first three.

The latter approach appears to be the most feasible to apply to the AAW training research plan under discussion here today. It will not be a monolithic structure. Rather, it will consist of a number of relatively independent research efforts, funded from several sources, but knit into a well-coordinated team approach to training research. Although, it will be a program built out of bits and pieces, it should behave as if it were unitary. Insofar as this can be done, it will be accomplished through effective coordination. To be a genuinely integrated program each task associated with it must be undertaken with specific reference to an existing master plan and with detailed knowledge about the other efforts that are underway. Collaborative research planning would appear to be worthy of greater popul ity. In any case, it seems most desirable to evolve more effective methods for integrating the many different research projects that are underway. And, it seems sensible to do this within specific problem areas, such as AAW training.

It appears that there will be coordination requirements regardless of the form the AAW training research program ultimately takes. Coordination can make essential contributions to the more general goals of: (a) relating the separate training research efforts to each other, (b) accomplishing the desired research with a minimum of interference with on-going operational AAW training, and (c) welding the administrative and research groups into an effective working team.

Now, it is very easy to talk about coordination in some vague general sense. However, as we all know, coordination is more than an air of camaraderie, a good-hearted willingness to cooperate if called upon to do so. My purpose at this juncture is to specify some of the functions of coordination.

The first of these is the information function. This includes the exchange of formal and informal information among the participants. Hopefully, each participant will feel obligated to get information about his own work into the hands of each of the other participants. Further, he should feel obliged to read and understand the relevant work being accomplished by the other members of the team.

Of course, there are many other ways that information exchange can be fostered. This meeting is one way. Other meetings are anticipated. The group has been invited to visit other laboratories to see their facilities first hand. Another possibility is a newsletter to call attention to relevant work and report progress. A less formal device, such as a round robin letter might prove very useful. I am sure that you could suggest others.

The information function also entails storage and retrieval. Because some information specific to AAW is not generally available, a central repository of such information is desirable. Access to it could be by request for some specific item of information or for the loan of a particular document. In many cases, the kind of information needed by AAW research is classified. This of course complicates matters. In those instances where the information cannot be made available to each and every researcher, the possibility exists that the central repository could serve as a reference library for those fortunate to be in its vicinity. In any case, there should be at least one place that would contain copies of all of the relevant information.

Such a central repository could be drawn upon to prepare reports of the total endeavor. This would not only hold down the reporting requirements for separate contractors, but would present a more coherent account of the program to those interested in the program's progress.

In a similar manner, coordination would be improved if a briefing facility could be developed which would present information concerning the scope and progress of the various projects. This might use visual aids generously to assist those interested in reviewing the program with brief, authoritative summaries showing the projects involved; how they related to each other; the goals of each; and progress to date. Copies of this information could be made available periodically to all participants so that they could benefit by knowledge of the "big picture."

The maintenance of adequate liaison with the military is very important. Needless to say, it is burdensome to the operating Navy and to the training schools to have to deal directly with many different contractors. Furthermore, it is quite confusing to them. It is important to the success of the enterprise that we all draw upon the pooled resources of the "team" to the maximum extent while minimizing "get acquainted" field trips and direct requests to the operating activities. Perhaps periodic briefings can be arranged where the military can cover the points of interest more efficiently than could be done in a string of separate visits. This is done routinely in the ASW field.

Of course, it goes without saying, that a central source of information could serve as a briefing center. This could include the orientation of new research workers who are undertaking research in AAW. Similarly, briefings could be held for military officers entering billets where a knowledge of the training research program is essential. Perhaps this, too, could serve to limit demands upon military operations and training personnel.

There are some of the coordination functions as they are now perceived. To date they have been carried out by ONR, BuPers, and NTDC with a big assist from Human Sciences Research. However, we are frankly fumbling to evolve to best possible means for accomplishing coordination within existing restraints. The present reliance upon HSR may prove to be a stop gap.

In any case, it is essential to emphasize that effective coordination can not be imposed upon such a group as is represented here. Its realization depends upon a belief in its value and a willingness to contribute.

Relevant ONR Research

Glenn L. Bryan

John Whittenburg and Ed Weiss have described two studies that are part of the formal structure of the AAW training research plan. Returning to the analogy I used earlier, these are vertebrae, the planned research in direct support of AAW operational training. We now turn to the ribs, to the ongoing and planned research studies, both in-house and within the contract programs of research supporting organizations, that have relevance for AAW training. These will be covered in overviews of programs by representatives of research-supporting organizations and in more detailed reports on specific research projects by the investigators involved.

I will report briefly on some of the studies in the contract research program of the Psychological Sciences Division of the Office of Naval Research which relate to AAW training. The total program consists of some 200 contracts and grants, primarily with university and commercial research organizations covering a fairly broad spectrum of research. The general areas of psychology covered are fairly well specified by the titles of the four branches that make up the Psychological Sciences Division: Physiological Psychology, Group Psychology, Engineering Psychology, and Personnel and Training, although the latter title does not suggest the substantial program of basic human learning research that is supported.

The problem of deciding what is relevant to any given operational area is difficult when one is considering a basic research program.

Virtually the entire program can be thought of as relevant to some degree if one's frame of reference is simply that man is involved in the system. I have chosen, however, to restrict my selection of tasks and program areas to those which have a reasonably direct relationship to AAW training.

The work that John Whittenburg has just described is conducted under ONR contract and is, of course, the most relevant of our tasks, serving as it does as a provider of basic information for the training research plan. The research at Princeton under John Kennedy and Harry Schroder which we will hear more about later is jointly supported by the Group Psychology and the Personnel and Training Branches. Bob Glaser and Dave Klaus will discuss the program of their Team Training Laboratory at the American Institute for Research in Pittsburgh. This too is part of the ONR program. So is Joe Rigney's program at the Electronics Personnel Research Group at the University of Southern California. The personnel support ship concept that Joe will describe today represents the development of a idea that he and I have shared for some time but it is not representative of Joe's larger program at USC. The general mission of his project is to conduct research in areas of training, selection, classification, and other human factors problems as these relate to the operational employment and maintenance of electronic equipment by personnel in the Fleets. In addition to earlier directly relevant research on CIC personnel, Joe's more recent work on criterion development for digital computer personnel and maintenance technicians certainly seems to have promise for applications to AAW training.

Bill Vaughan of HSR has been analyzing the tactical decisions employed by submarine commanders under an ONR contract. He is attempting to distinguish the several kinds of data processing operations that are performed and the criteria employed. Ultimately he hopes to provide a basis for optimum assignment of decision tasks to men and equipment in command-control systems.

We also support a number of basic studies of the human problem solving process. Howard Kendler at the University of California (Santa Barbara) and Donald Taylor at Yale are examples. We have recently initiated a contract with John Swets at Bolt, Beranek and Newman which might have some pay-off for AAW. It involves the use of computer-based systems to teach complex concepts. In this sense, however, our entire program of learning and training research has at least some relevance for the immediate problem at hand.

The small group research supported by our Group Psychology Branch, particularly those studies which concern themselves with group composition are relevant.

Physiological Psychology and Engineering Psychology support research in a number of relevant areas. Their work on cutaneous and voice communications, on visual and auditory displays, on optimum illumination levels, and on vigilance behavior, to mention only a few, have implications for training.

In short, it has been my purpose to give you a sample of the broad range of ONR-supported research which has potential applicability to problems of operational training. More specific information will be presented by our contractors on the program.

AAW Training Research at U. S. Naval Training Device Center
An Overview

James J. Regan

Thank you, Dr. Bryan. I never cease to be amazed at how orderly and almost rational this plan appears to be in the telling, when in fact there is so much anarchy and fortuitousness associated with it. This is not to suggest that it is therefore any less useful as a heuristic document. On the contrary, we hope that in regarding it as something less than fully determined, you will be encouraged to contribute to its continuing formation.

I should like to say a few words, if I may, about the role that the Training Device Center plans to play in this effort. In the course of doing this, something will be said about the research effort at the Naval Training Device Center, which has as its focus the training environment. We worry mostly about training equipment and systems for the Navy, the Army, and, to some extent, other agencies of Government. It is not always easy, in terms of this training equipment mission to abstract from the general training problem those special aspects of that problem which bear specifically and exclusively on the design of training hardware. I should like therefore to suggest that although training systems and hardware represent the focus of our research effort, we are not always in focus. However, I believe when you hear the reports of some of the people who are conducting research under our sponsorship you will recognize the central question which we always ask of our contractors and ourselves, "What is the extent and character of the required simulation?" We refer here to that simulation required to enable students or trainees to develop those behaviors which they must exhibit operationally. I should like now to give you two research examples of an historical character that ask important questions about simulation.

One has to do with the problem of vehicular control. This area has interested psychologists for a long time and has interested the Center specifically in connection with teaching people to control a variety of vehicles such as submarines, aircraft and tanks. One of the more expensive aspects of training equipments designed to promote vehicular control skills is the computational feature required to simulate the dynamics of some given vehicle. These dynamics are what intervene between the output of the student and the response of the system in question. Research at the Electric Boat Company some years ago showed that rather significant departures from the operational dynamics were possible without any serious loss to the trainee. Such departures could take the form of reducing or eliminating certain cross-coupling terms and other non-linearities. The measure of performance in this instance, as with unfortunately many others, was the inevitable intermediate criterion -- in this case the most elaborate simulation of vehicle dynamics at that time available.

A related problem with respect to the extent and character of simulation occurs when one asks questions about the specificity of training equipment. This question arises, for example, when one looks at tasks related to radar scope interpretation on a variety of radar equipments. One of the consequences of this operational equipment variety is the proliferation of specific radar and sonar training systems designed to parallel physically the operational equipments in the field. On the other hand, there is some belief that much of the variance associated with skilled operator performance on these equipments is not specific to any given radar set. We have some indication that this is in fact the case and there is some research in our program directed at specifying the circumstances under which generalized perceptual training is useful and how much of what one must ultimately have in the way of skill can be accounted for by a universal or generalized-type trainer.

Both of the research programs to which I have alluded and in fact much of what has already been said this morning directly, I think, relates to AAW. However, it does bring up a question about which I should like to talk a little more fully somewhat later, and the question is this, "How different would what we have said this morning, and are likely to say and hear for the balance of these two days, how different would this material be or would the emphasis be were we to substitute the letters ASW for AAW, or for that matter the letters AEW or any other A's of which you may be aware?" There is, I believe, a fair amount under way and proposed in this plan which, although useful to AAW training, is by no means peculiar to it. Therefore another of the questions I think we ought to try and answer is, "How worried should we be about this, or should we be anything but worried about it? Should we take advantage of the characteristics of the plan which allow us to do a variety of things which will be useful at the same time to AAW and other operating training situations?"

Dr. Bryan mentioned the fact that this plan represented a sort of club; and the more I think about this club, the more it seems to me that the qualifications for entering are not restricted to any particular kind of training research. I in fact heard Mr. Friedman say that we were not confining ourselves to training research. However, let us assume for the moment that we are concerned primarily with training research and the implementation of research findings already in existence. I guess we could categorize the participation of the Center and its contractors in three categories of club membership related to training research. One is direct, the second is indirect but specified, and the third is essentially unspecified. Let me now describe for you very briefly a few examples from each of these three categories.

The first one, of course, is the Matrix Corporation's contract about which you have already heard. They are charged with the development of a plan of research for AAW and with laying out some quick fix solutions to problems that they uncover in their investigation of AAW. I am not going to talk further about this program, for the reason that Dr. Weiss of Matrix Corporation is here specifically for that purpose and also because being here he is in a position to correct any mistakes or oversights that I might make should I attempt to do so.

The second project especially directed to AAW is one that you do not see on the plan. It's the third bone protruding from that fish, and it has to do with systems analysis. It represents an operations analysis approach to the problem of AAW training. Specifically, it is an attempt to find out where in a complex system such as AAW one might most profitably apply one's limited training resources in improving operational performance. Said another way, this would involve determining, in terms of time or dollars or some other appropriate measure, which improvements in one or more of a variety of subsystems making up the AAW system would, if operated on from a point of view of training, have the most substantial effect on the overall system performance.

The second of our three categories of club membership has to do with a part of the program at the Center which is referred to as the Applied Research Program. There are two projects in this category, each of which was redirected slightly to make its products somewhat more germane to and useful for the AAW training plan. This redirection which took place a year or so ago came essentially to asking the researchers, who incidentally are both here, Professor George Briggs of Ohio State University's Laboratory for Aviation Psychology and Dr. Raymond Sidorsky, Head of the Human Factors Section at The Electric Boat Division of General Dynamics, to learn about AAW operations in the Navy. Following this, they are in their laboratory experimentation to form some tasks which bear relationship to tasks performed in fleet AAW operations. This request, although minor on the surface, is of some importance, I think, for the reason that in all of the research, or in at least much of the research which we sponsor, it is becoming increasingly apparent that a factor of central importance in deciding on which of a number of alternate ways of developing some specified behavior is the most successful is the characteristic of the task abstracted for laboratory manipulation. The results of experimentation, I am beginning to think more and more, are importantly related to the characteristics of the tasks devised for laboratory experimentation. Thus, although these changes may appear at first to have little effect on either of these two research programs, they will make much more meaningful in terms of AAW application those results that will be forthcoming. Again, I plan not to present any detailed description of the work at either of these laboratories, since their directors are here and plan to do precisely that today and tomorrow.

The third and most indirect category of club membership is represented by much of the balance of our Applied Research Program and to some extent our Psychological Research and Development Program. I plan only to allude to this selected sample of the balance of these programs, and I hope that if any of these items prove to be of special interest to you that during the next two days we will have some opportunity to explore them in greater detail.

The first has to do with something called adaptive training. This idea of adaptive training can most dramatically be expressed by describing the differences in a typical learning curve that would result between the normal or conventional learning situation and an adaptive one. Ordinarily, one would expect to see a learning curve changing over time from some relatively low percentage of success to something approaching 100%, let's say. In an adaptive system one would have a learning curve with an essentially zero slope. The characteristics of the training system or training equipment would be changing with the changing skill of the student. The students' performance would be more or less fixed at some as yet undetermined level of success, say between 40 and 60%. A measure of how well the student did would be the state of complexity of the training system at the end of training. We have some research under contract and the beginnings of some work in this area in-house.

A second item which bears directly on the design of training equipment which is of some interest to us has to do with feedback. By feedback I refer here to supplemental, augmented, action, and learning; in general any information to the trainee about what he has or has not done. Feedback may be compared with cuing; defined as information presented before or during the stimulus presentation. For example, if one were presenting a scope picture with a lot of noise in which was imbedded a target and we wished to have the student learn to identify this target, one might encircle the target electronically -- put a hook around it -- and thus provide an important cue to the student in his attempts to localize the target. Feedback in the same situation would result from telling the student after he had attempted to identify the target whether, in fact, he had done so correctly. We have some work now which is nearing completion at the Universities of Sheffield and Aberdeen in England which is concerned with the relative merits of feedback and cuing. There are two interesting points that we are finding or tending to find in this project and in some work performed by Dr. Swets of Bolt, Beranek and Newman. Cuing in many situations tends to be more beneficial than feedback. A second point of interest, particularly from the point of view of training equipment, is that the characteristics of cuing are going to vary as a function of the kind of task involved. For example, if one were learning to identify a tone in noise in an auditory situation, an appropriate technique for cuing would be to bring the level of the signal beyond that of the noise or conversely to reduce the noise thus changing the signal-to-noise ratio, thus making the problem of identifying the sound a much simpler one. On the other hand, if one were faced with an analogous visual problem of identifying a target on a noisy scope, rather than reduce the noise or brighten the target, thus changing the signal-to-noise ratio, a more appropriate cuing technique would be to present the target picture as it would appear ultimately and to encircle or in some way point out to the student where the target is. We are just beginning to get some feel for the variations possible in this form of cuing and, for that matter, some of the more specific features of feedback.

These then constitute some examples of each of the three categories of NTDC membership. In fact, it constitutes all of the projects in Category One and Two, and selected samples of Category Three.

I should, by way of conclusion, like to raise several questions that came to my mind as I sat here this morning. One, I have already brought up in asking the question about AA versus AS and AEW. A second relates to the difficulties in making or reaching decisions either in the formation of a training plan, or for that matter in a systems analysis which derive from a lack of quantitative information concerning the output characteristics of the system with which we are concerned. Suppose one were able to say that the AAW system must in some given time and under some specified environmental situation destroy X targets in Y time and that, in fact, we were shooting down X minus some value (targets) in Y plus some value of time. And further, if one were to make certain changes in the training program, one could effect certain changes in these criteria, then we would have a rather specific handle with which to approach the problem. This then becomes a manipulable bit of information which I am not too sure we have right now. I am not even suggesting that we can't proceed until we have this kind of information fully in hand or for that matter do I believe that there is a great likelihood that it will ever be available in quite the form I've described it. It does, nonetheless, seem important to develop some estimates in quantitative terms for use in allowing us to arrive at common decisions with respect to what in the system from a training point of view ought to be attacked.

There are several research issues which might be reflected in the plan. The first has to do with the extent to which the characteristics of the task or task specificity influence the methods or techniques which we might suggest as being optimum in some given training situation.

The second is the general area of computerized learning systems. I'm sure you've all heard a great deal about this area and probably most of you are a good deal more familiar with its problems and potential than I am. It would seem that the presence of computers in operational systems is at once creating new and difficult human performance situations for which adequate training solutions have yet to be determined and at the same time opening up opportunities for rendering much more efficient, a wide variety of training environments, many of which haven't changed in centuries. In connection with computer-based instructions, work that we have sponsored at Bolt, Beranek and Newman as well as some of the work in the teaching machine or automated instructional area is providing us with some new insights about widely held principles of learning. Such practices as constructed response and small step, errorless learning, for example, frequently, or at least under specified circumstances, do not promote optimally the acquisition or transfer of material. Particularly in the case of associative learning, it appears that a straightforward sort of "brute force" learning situation is at least as effective as some of the more elaborately organized learning environments.

There is also a matter of individual differences. Psychologists have long recognized that individuals do in fact differ in a variety of ways. On the other hand, at the end of some period of training we expect a group of personnel to emerge with common skills. It also seems that in general there is some one standardized way of attempting to develop this common level of proficiency. One of the questions we then might ask ourselves is whether or not we might bring a group of individuals more quickly and efficiently to some specified common level of proficiency by providing non-standardized techniques for getting there. That is to say, we might recognize the individual differences and alter the structure of the course or more specifically the method of presenting the information as a function of one or more identified dimensions of differences.

One point about AAW training equipment Dr. Bryan quite correctly pointed out this morning -- that there has been, are now, and probably will continue to be a number of rather expensive and elaborate training systems. Examples of this elaborate equipment include the training facility at Dam Neck, its sister facility at Point Loma, California, the tactical facility at Norfolk, and the upcoming air defense trainer at Glynco, Georgia. It is a characteristic of these and many other group tactical trainers that they are essentially unstructured. It seems therefore that we should, in addition to being concerned about the specific characteristics of the equipments (i.e. the displays to the students, techniques for feedback to the students and instructor control of the training), also be concerned with techniques for employment. This is especially true precisely because these large training facilities are so unstructured educationally. I believe the opportunities to improve these training systems already in existence lie more in the direction of improved employment than in the d[illegible]ction of re-design. I think efforts toward design probably should be di[illegible]ted toward entirely new training equipment complexes. The Fleet, far from being unwilling to accept assistance from people such as ourselves is, in my experience, quite anxious to accept such employment materials as problem scripts and to avoid providing this assistance on the grounds that Fleet personnel wish themselves to decide how to train is the height of rationalization.

I am not at all certain that this kind of activity is quite properly described as training research and perhaps it is not. In any event, it brings me to the last of the several points I wish to make. Although the label of this effort is the development of a training research plan and the conduct of training research, there is, I suspect, a fair amount of activity which can take place under the general aegis of this effort which is not properly training research at all. For example, the application of existing information derived from research in human learning and training and to situations in Fleet training and elsewhere would seem to be a useful contribution.

Now that was the first final point. There are one or two final, final points I should like to make concerning the features of this plan which are particularly appealing to me. One is that it isn't really as organized as it would appear to be in the telling. This truth, in fact, enhances the interest of the plan for me. The second and perhaps more important feature is that the plan has engendered a considerable amount of interest at almost every level of the Navy. All of the years that I have been involved in working in Naval Research I have frequently been in the position of having to go hat in hand into Navy field activities requesting some limited amount of time and some limited form of cooperation in one of our research endeavors. Since the Chief of Naval Operations is supporting this plan in principle and in certain of its specifics, when in the future one or more of you or some other researcher attempts to obtain some information at a Naval operating activity, he is more likely to be able to obtain it and they are more likely to be able to provide the time and facilities necessary. At the same time, this places a responsibility on us for the coordination of an effort as large as this. Otherwise, irrespective of the level of support, the 250th contractor who makes his way into Dam Neck, Virginia, is going to be in some difficulty.

Another feature of the plan which is appealing is that it can serve to bring somewhat closer together two words -- R and D -- which appear in print separated only by the word "and", but which in reality are sometimes worlds apart. Not only does the plan provide for using existing data but that research which is engendered by the plan itself will, within the plan, have an opportunity for implementation. In fact provisions are made for employing in a trial fashion in operating units the results of the research effort.

That pretty well concludes what I have to say. Are there any questions?

Relevant BuPers Research

Sidney Friedman

I should first like to indicate, by way of introduction, that we of the Bureau of Naval Personnel, Research Division, are grateful for the opportunity to meet with all of you to discuss mutual problems in the important area of Anti-Air Warfare Research. I am sure I speak for each of my colleagues and co-workers, Drs. Earl Jones and Ed Rundquist of our Training Research Laboratory in San Diego, and Mr. Al Sjoholm who, like myself, is located at Research Division headquarters here in Washington.

Second, I should like to tell you that I was a very small part of a very determined effort begun over a year and a half ago, largely as a result of the untiring efforts of Glenn Bryan, which was designed to come up with a part of an ideal program package of research in AAW. As part of this effort, I accompanied Glenn Bryan and others on at least two trips to Dam Neck, to hear about and discuss problem areas in AAW operations and to think about ways in which they might be solved. I was overwhelmed by the magnitude of the problems as presented; but was encouraged by the attitudes and opinions expressed with regard to the recognition of the importance of a well-designed systematically developed research program as a probable only means for solving these problems. I must also admit, however, that my input to the thinking and actual planning effort expended to achieve at least the draft of such a program was extremely small by comparison with Dr. Bryan's and Dr. Regan's efforts. Nevertheless, we still see ourselves as being vitally concerned with this program. So I will try to tell you a little bit about things we have done in the past, what we are now doing, and what we plan to do, insofar as these things have relevance to the overall AAW Research Program as described by Dr. Bryan.

Our interest and efforts in this general area go back many years -- long before people spoke of an AAW Personnel and Training Research Program. For example, about 12 years ago we attempted to validate some of our experimental officer calssification tests against success in CIC training, and appeared to meet with some success, by way of some modest validities against school criteria. This effort, however, was doomed by the administrative consideration that all line officers were expected to succeed in this kind of training, and that if they didn't, training would have to be modified so that all would pass. Also, as our modest friend Glenn Bryan will recall, in 1953, (I think) we asked the EPG at Southern California, under contract with ONR, to conduct research on CIC officer requirements and standards aboard ship. A report on this effort was published in 1954 by Dr. Bryan.

We have, also in the distant past, supported the conduct of research on contract with ETS, designed to obtain a better understanding of what one of our officer tests, namely Relative Movement, which was peculiarly designed to be predictive of the kinds of things CIC officers are supposed to do, was actually measuring.

In addition, we have from time to time concerned ourselves with piecemeal problems related to selection and training of various enlisted ratings. We feel that the findings of some of our studies might be germaine to our problem at hand insofar, at least, as they might reveal profitable or non-profitable approaches as we attempt to put all the bits and pieces together in our effort to obtain some sort of meaningful whole.

More recently, and particularly over the past 3 to 4 years, the BuPers program has devoted a sizable effort to personnel research associated with new hardware developments. As one might suspect, much of this work has been, and still is, connected with Surface to Air Missiles and Missile Systems, as well as on the Naval Tactical Data System -- Essentially work along these lines may be divided into 4 broad categories - first, that which is concerned with the predictive aspects of personnel and training requirements; second, work concerned with the development of proficiency tests on specific weapons and weapons systems or subsystems; third, work concerned with development of administratively usable and useful training feedback procedures; and fourth, work connected with the evaluative aspects of testing the personnel subsystem as part of the overall OPTEVFOR evaluation procedures.

More specifically, I might mention that efforts, particularly in the first two categories has either been completed or is well underway on such systems as Tarter, Talos, Terrier, Typhon as well as the AN/SPS-48 and 49 Radars.

I have a little more detail covering the type of research covered in connection with the Tarter system, if such details are desired at this time. Otherwise, I shall merely indicate that an annotated bibliography covering most of the work referred to can be made available on request.

Detailed reports themselves are generally classified and might be available consistent with governing security procedures. If you do have any other specific questions concerning the New Developments Research Program, I'm sure that Al Sjoholm, who heads the program in BuPers, will do his best to answer them.

Which brings us to now -- But going back a bit to the general plan described by Glenn Bryan, you will recall that I indicated that I did try to contribute some small somethings to the thinking which went into the plan. These small somethings took into account the plans we had to expand our overall training research effort, which I'm most happy to report, we are now well on our way toward accomplishing (I will leave it to Drs. Jones and Rundquist to fill you in on some of the details and to answer any questions you might have, after they have made their presentations.) In any event, we felt that dependent on the phasing and outcomes of tasks 01, 11, 12 and perhaps 13 - we should be ready, with our expanded training research effort, to undertake work on Tact 20. As a matter of fact I believe that Dr. Rundquist's presentation will reveal that we may have already begun to do so. And, so I'll let that one rest.

With respect to item 22 I feel that whereas I agreed in principle with the need for such kind of research I am at present not quire sure as to the direction or order of magnitude of effort which we in BuPers might be prepared to undertake in this area.

On this note of uncertainty, I should like to again express my gratitude for having this opportunity to speak with all of you in this informal, relaxed atmosphere, thanks to our chairman and our hosts.

General Comments Concerning the Work of the Navy Training Research Laboratory and the Research in the AAW Area

Earl I. Jones
Bureau of Naval Personnel

Having been given the opportunity to address this group, there are four kinds of remarks I wish to make.

First, I wish to thank all those responsible for planning this conference for inviting Dr. Rundquist and me and for their excellent hospitality.

Secondly, I want to touch briefly upon the first three sub-objectives of the conference as outlined in Attachment 1. With respect to sub-objective "a," I think the major problems are communications, acceptance of a common goal, delineation of responsibility, acceptance by the military, and the sheer, hard work by someone to see to it that coordination occurs. My personal impression is that Glenn Bryan and others have accomplished a major step toward coordination in establishing this conference and doing the great amount of spade work which was required to get this group together. With respect to sub-objective "b," it appears to me that our old friend, the criterion problem has again reared its ugly head and can be succinctly described as a critical methodological problem. With respect to sub-objective "c" my only comment is that as a result of this conference I have been learning what some of the major problems are perceived to be.

My third set of remarks concerns the program of the Navy Training Research Laboratory and its as yet brief encounter with the AAW area. In regard to this set of remarks I wish to correct an impression which may have arisen because of some remarks made yesterday by Mr. Friedman. In reference to Task .20 of the plan presented by Dr. Bryan, Mr. Friedman suggested that the Navy Training

Research Laboratory was already working on Task .20. This is not entirely true. It is entirely and unintentionally untrue and resulted from the fact that one of our tasks has a title which bears some resemblance to the title of Task .20.

Let me briefly outline the Navy Training Research Laboratory's current program. We have underway or in planning training research projects in ASW, Electronics, Aviation Technical Training, Shipboard Training and AAW. Except for a couple of crash projects over the years we are newcomers to the AAW area. However, some of our previous work in the areas of ASW and Electronics does, I think, have implications for AAW. Several of our early ASW studies by Angell and Kuhn were directed at the team criterion problem. We were able to construct standard runs (attack problems in which the maneuvers and speeds of the submarines were controlled) which represented stable mean levels of difficulty. Criterion measures employed were location error (the error in yards from ordnance explosion point to submarine center at time of fire center on the recorder trace), a total run score obtained from center bearing, collision course, attack lead, pattern location error, and kill--each scored on a five point scale, and kill (hit or miss) by itself. As would be expected, these measures correlated highly (.80) with each other. The measures discriminated reliably between runs (i.e., problem difficulty), but no reliable discrimination could be made between team performances for the 20 teams used in the study.

Angell, in another study, constructed a check list of A/S officer performance in single ship attacks whose test-retest reliability correlation was .75 for an A/S officer student group and .53 for a Deck Officer student group. The test-retest reliability correlation of the total attack error scores on the A/S officer group was .48. The correlation between check list total scores and total attack error scores for the Deck Officer group was not significantly different from zero. For the A/S officer group the correlation between check list total scores and total attack error scores on the retest was .34. This is significantly different from zero at the 5 per cent level of confidence. It can be seen that both a check list of officer performance and attack error are sufficiently reliable to suggest further use, especially for research purposes.

To summarize these studies then, it appeared that by using standard runs of known difficulty, attack error might furnish some measure of team performance if further refined. Conning officer performance contributed a significant portion of the variance in team performance. With perfected attack error scoring techniques and with teams of greater training and experience differences, teams might be ordered on a continuum of proficiency in terms of location error scores.

Roemmich carried out another set of studies in our early efforts in ASW team training research. This set concerned an evaluation of the then current status of ASW team training. One peripheral finding from this work which might be of interest here concerned team members perceptions of the characteristics of "good and "poor" ASW teams. Since "poor" characteristics were, for the most part, simply the opposites of "good" characteristics only those "good" characteristics frequently indicated by team members will be listed here. They are:

1. Proper application of procedures, doctrine, terminology (Smoothness, frequency and accuracy of information).

2. Good supervision, leadership, and good discipline. Leaders have control of team at all times.

3. Teamwork and coordination betweer t^am members, e.g., understanding the use and purpose of reports, and working together and anticipating actions and needs of others.

4. Individual competence on own job and jobs assigned when rotated, e.g., Conn knows tactics, stack can hold contact, A/P relays and checks information, and everyone follows doctrine.

5. Good attitude and interest on part of men.

6. Confidence of men in officers and officers in men. Also mutual respect among officers and men.

7. Complete cooperation between Bridge, CIC, and sonar.

I would like to shift now to a different aspect of NTRL's work. A commonly recognized fact in the Navy'is that maximum operatior or equipment proficiency is limited by the condition (alignment, calibration, etc.) of equipment. Consequently, ability in electronics maintenance is vital for fleet readiness in ASW, AAW, or any modern warfare area. For several years our training research efforts have included a large proportion of work concerned with problems in the training of electronics personnel. From several objective surveys of the performance of Navy technicians it became obvious that in a number of ratings the "average" ability of technicians to carry out required maintenance was below the level needed for adequate maintenance. To date, we have worked on problems related to the training of ET's, AT's, SO's, AE's and AM's. We are currently doing evaluative studies of the training and performance of MT's, DS's and FT's. These latter three ratings have responsibilities related to AAW readiness. Because of the Navy's rating structure and system of distribution and assignment of personnel, one of the continuing and vexing problems concerns training which is highly and specifically oriented toward one or more specific pieces of equipment. ET's, for example, are responsible as a group for the maintenance of more than 240 different equipments. Since formal training on the maintenance of all of these equipments cannot possibly be provided, the planning of training which can yield maximum transfer and generalization is a major problem. Much of our current effort and future plans in Electronics training deals with this problem. I will not go into further detail here, but I hope that I have made the point that there is a considerable amount of research not aimed directly at the AAW problem which does, nevertheless, have important implications for AAW readiness.

As for research directly concerned with AAW, the main reason we have done so little in the AAW area in the past is the result of polite, cold resistance on the part of those responsible for AAW to our research overtures in past years. The reason we are now working in and developing plans for further work in AAW is the result of three main influences: (1) the good fortune to have established rapport with the Commanding Officer, FAAWTC, San Diego, (2) the good fortune of having been invited by Glenn Bryan to participate in this area, and (3) the good fortune to have had a man recently join our staff after spending several years with SDC, Santa Monica. This leads me to the fourth and last set of remarks I wish to make. I would like to introduce Dr. Edward Rundquist, our man from SDC, who will describe for you the modest beginnings of our program in AAW training research.

Current NTRL Work in the AAW Area

Edward A. Rundquist
Bureau of Naval Personnel

It would be difficult to spend a number of years at SDC and not develop an interest in team training -- in such problems as influence of individual task allocation, group structure and group compatability on group performance. In pursuing this interest in new (Navy) surroundings, however, one must first become acquainted with the setting before determining how this research interest can best serve Navy purposes. With respect to AAW we, like the German philosophers, are beginning doubtfully and far away.

As part of my own education in Navy characteristics and problems I took the CIC Watch Officers Course offered by FAAWTC, San Diego. This experience roused my interest in the problem of determining course content under conditions of severe time constraints relative to the material to be covered -- ASW, Surface Operations, Amphibious Operations, and Anti-Air Warfare Operations -- to mention only the major areas. We have embarked on a cooperative venture with the instructors of this course to redesign it -- a venture in curriculum engineering. It is hoped that ultimately a technology can be devised for instructors to follow in designing and redesigning a course. Even in the early phases of the work we have run into many of the problems already mentioned at this conference -- particularly the problem of definition of terminal behavior the course should aim at achieving. There is so much variation in the way ultimate performance is achieved on shipboard that we are finding it rough going to specify course objectives precisely and in terms which will permit asking meaningful questions about each to permit evaluation of the criticality, level of skill required, and so on, in order to aid in the rational selection of course content.

Even less related to the AAW problem is a study of methods of maneuvering board instruction. As you probably all know, the maneuvering board is an aid for the graphic solution of problems of relative motion -- such problems as intercepting another ship or determining course and speed to arrive at a specific position in a changing formation.

A substantial part of the CIC Watch Officers Course that I attended was devoted to maneuvering board instruction, despite the fact that students were supposed to arrive at the course with this skill. The immediate practical problem being investigated is whether there are differences in the ease of solving the problems using own ship in center, other ship in center, or either ship in center -- three methods which are in current use and about the efficiency of which there is dispute.

We have a longer range interest -- the investigation of the role of conceptual models in learning and retention. Dr. Whittenburg has presented us with an admirable series of conceptual models in his presentation. Every instructor uses diagramatic models like these in his teaching. I have a suspicion, however, that these models are n fully exploited in instruction.

Further, these models may well differ in effectiveness for different ability levels. In terms of this long range interest, the maneuvering board will serve as a vehicle for studying different conceptual models. From this point of view present studies are serving to provide information about the kind of models that should be studied -- vector, the physical world model, the relative motion world model, etc.

A study more closely related to AAW is concerned with methods of training programers for NTDS. Many senior officers with no engineering background have been having difficulty with this course. We were asked to determine whether a method of instruction could be devised to help this group. The study can be considered as a companion to the attempt of Rigney's group to develop aptitude tests for the selection of programer trainees. Dr. John Meyer of my staff took the course to get some ideas on this problem. On the basis of his observations, a program is being initiated which includes what seems to be a universal problem in training -- deriving explicit statements of objectives -- as well as experiments in the NTRL laboratory. We are planning to study the influence of the amount of practice and techniques for promoting active student participation on learning to code and to flow diagram.

Practice was selected as one experimental variable because of the observation that some students become lost early in the course and never do catch up. More practice and instructional time may be needed by students who have not had experience which makes it possible to think in the explicit way demanded by flow charting and coding.

Techniques for promoting student participation was selected for study on the basis of the observation that in review and discussion sessions of the course there was little student participation, perhaps because those who had no problem saw no need for questions, and those who were having troubles, had insufficient grasp of the subject matter to be able to formulate questions. A technique for promoting student participation in small groups will be compared with the current method of instructor presentation and discussion in the large classroom setting.

As I have said, these efforts are but indirectly related to operational AAW. It is hoped they will provide the background needed to understand the AAW problem and lead to more relevant studies of team training in the NTDS setting, supplemented by appropriate laboratory studies.

Study of Generalized Decision-Making Skills
(NTDC Project 7576)

Raymond C. Sidorsky
General Dynamics/Electric Boat

I'm going to report on the progress of a research program at Electric Boat supported by the Naval Training Device Center.

The overall purpose of this project is to provide empirical foundations for the training of decision-making behavior. More specifically, to identify by operational definition those aspects of decision-making behavior used in AAW and ASW; to determine empirically which aspects are most responsible to training; and to determine empirically which aspects are generalizable or specific to the task at hand. Our efforts to date have included information gathering from NWPs, NWIPs, and other naval publications, interviews and discussions with present or former naval officers knowledgable in AAW and/or ASW, and analytical study of the fundamental nature of military decision-making tasks.

In keeping with our charter from NTDC, we have endeavored to maintain a global approach to the general problem of decision-making rather than addressing ourselves to the detailed characteristics of specific tactical situations or operations. To this end we have defined our initial problem as the determination of what decision-makers are required to do in relation to an actual or potential enemy rather than a determination of what they should do or of how they should do it. In other words, the results of this first phase of the program will be by and large descriptive in nature.

For purpose of this study, military decision-making is defined as the manifest assumption of responsibility, based on vested or implied authority for the selection of a particular course of action from among a known group of alternative actions which is intended to and capable of affecting the course of events related to an actual or potential enemy in such a way as to best satisfy some end or goal. Further, in order to provide a practical set of boundary conditions to the tasks which will be considered, a set of initial assumptions was developed as the context from which decision tasks would be selected. The following circumstances were assumed:

(1) state of war and, therefore, actual or potential presence of adversaries with objectives opposed to own;

(2) presence of unit or group of units capable of implementing successful confrontation of the enemy;

(3) existence of pre-determined, specifiable doctrines, strategies, or rules;

(4) existence of specific, quantifiable setting in time, space, natural, own, and opponent-engendered environment;

(5) existence of a unit role, defined by a set of prescribed responsibilities;

(6) existence of reciprocal understanding of units' role responsibilities and the expectation of performance of such responsibilities;

(7) presence of a mission, i.e., a distinguishable set of activities characterized by phases in which a unit engages when fulfilling a particular goal related to attaining national objectives; and

(8) the possibility that several missions may operate simultaneously, although they may differ in priority.

Our initial efforts have been directed toward the development of a conceptual framework which will permit the classification of decision-making on the basis of objectively defined parameters. This endeavor has reached at least partial fruition through the evolution of ACADIA* - A Taxonomy of Military Decision-Making. The rationale which has led to the development of the ACADIA system is based on the postulate that military (as well as other) decisions can be logically and usefully categorized on the basis of the dynamics involved in the relationship between combinations of pairs of the three basic determinants inherent in a decision task, viz: self, i.e. those aspects or attributes related to or under the control of the decision-maker, enemy, i.e. the external agent or entity to which own self must relate to achieve some objective, and the interface, i.e. those aspects of the physical environment through which various forms of interaction occur (data acquisition, physical contact, etc.). The postulation of these three elements has been derived by induction from the data gathered in the course of the literature review and interview processes.

In the ACADIA schema, a decision is viewed as an action resulting from an individual's attempt to best relate to external entities or agents to achieve some desired end based on perceived or expected relationships between self and the external entity. The nature of this response is determined by the particular combination of determinants operating in a given situation. Thus, decision-making is defined in terms of empirically observable characteristics of the decision situation. As a consequence,

*Acronym derived from the basic decision classes of Acceptance Change, Anticipation, Designation, Implementation, and Adaptation.

decision-making is treated not as a process but as a response which exists only in its manifestation. On this basis, six decision types have been delineated, viz:

	Decision Task Determinants	
	Source of Uncertainty	Criterion of Decision-Maker's Response Expressed in Terms of
Acceptance	interface	enemy
Change	self	interface
Anticipation	enemy	interface
Designation	interface	self
Implementation	self	enemy
Adaptation	enemy	self

An additional task to which we are addressing ourselves is the development of a coding system to provide a convenient method by which military decision tasks can be analyzed and regrouped. This coding system is intended to permit determination of communalities inherent in superficially disparate situations to which a common training procedure can be applied.

At present, characteristics of military decision tasks are being analyzed in terms of a number of different dimensions to provide a multidimensional framework for the projected coding system. In addition to the basic ACADIA categorization, the applicability of following dimensions to the derivation of a meaningful schematic is being investigated.

A. Situational Characteristics including:

Time

Space

Data

a priori { fixed / varying }

emergent

Response

Feedback

B. Contextual Elements including:

Self identities

Enemy identities

Goals

Values

Probability characteristics

Costs

Capabilities

To summarize, then, the analytic portion of the study we are conducting at General Dynamics/Electric Boat for the Naval Training Device Center has as its goals:

(1) The development of a logical and useful categorization of military decisions.

(2) A schema whereby communalities in various types of decision-making can be isolated for the purpose of training.

(3) Empirical determination of the relationships between the decision maker and the external world as pertaining to military decisions.

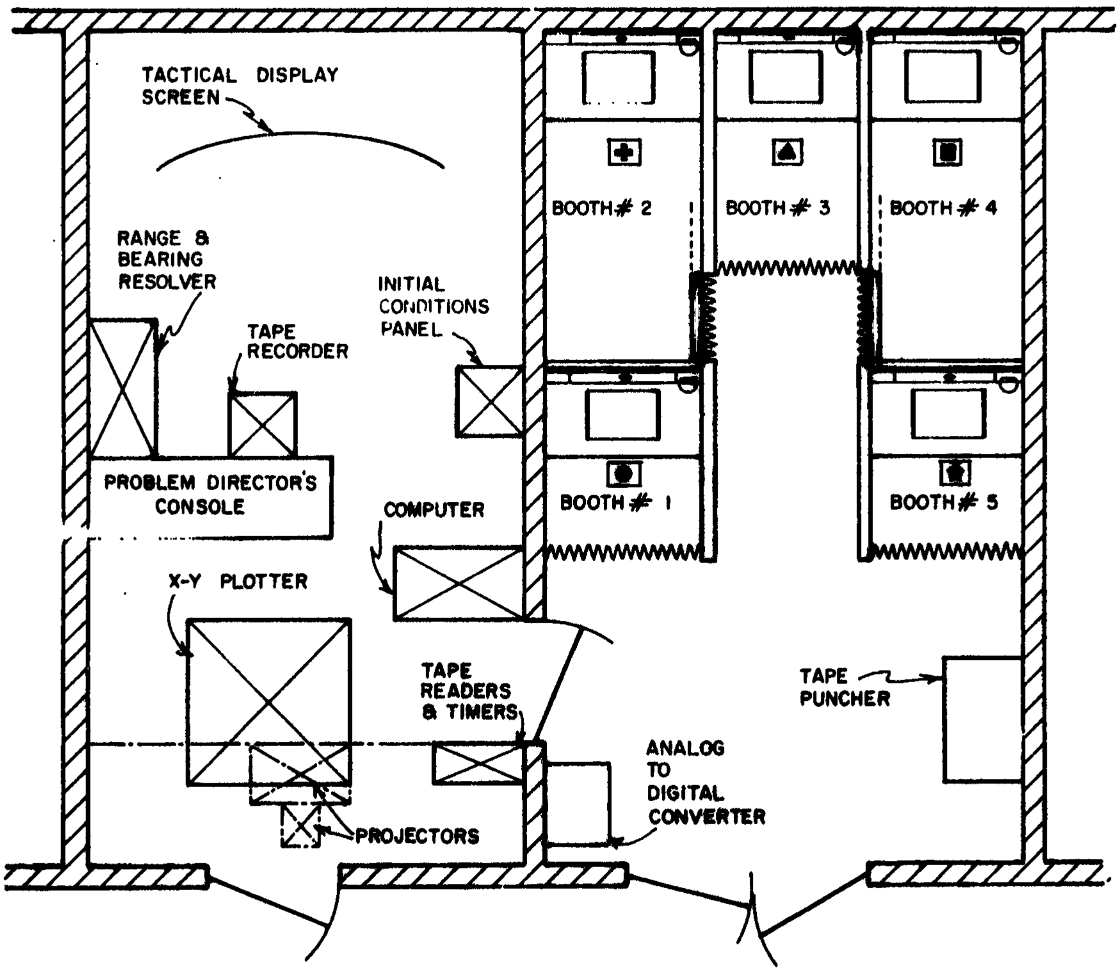
(4) Recommendations as to training procedures and training device designs necessary to provide fruitful training for decision making.

In addition to these analytic aspects, the research being conducted under the auspices of the Naval Training Device Center includes a program of experimental studies. The general objective of this phase of the project is to provide data on the human learning of decision tasks which can be applied to the design and employment of training equipment.

The empirical studies are being implemented through the use of SUBTAG, the Electric Boat SUBmarine Tactics Analysis and Gaming Facility.

SUBTAG is a man/machine gaming facility which employs analog computerization to provide dynamic simulation of various situational parameters. It is thus capable of presenting a wide variety of tactical, i.e. decision-making situations under "realistic" conditions. Physically, the facility is composed of two major areas, one containing operator control stations (booths), the second containing equipment and displays for experimenter control purposes. An overview of the facility is shown in Figure 1.

The command station area is composed of five stations or booths, each containing a console (Figure 2). Each console is provided with display indicators, controls, and communications equipment. The experimenter's control area, located in a room adjoining the command booth area, is equipped with a multi-coded situation display, control and monitoring equipment, data collection equipment, and the central communications panel (Figure 3). Analog computers for the provision of dynamic



SCALE:
1/4" = 1 FT.

FIGURE 1 SUBTAG FACILITY ARRANGEMENT PLAN

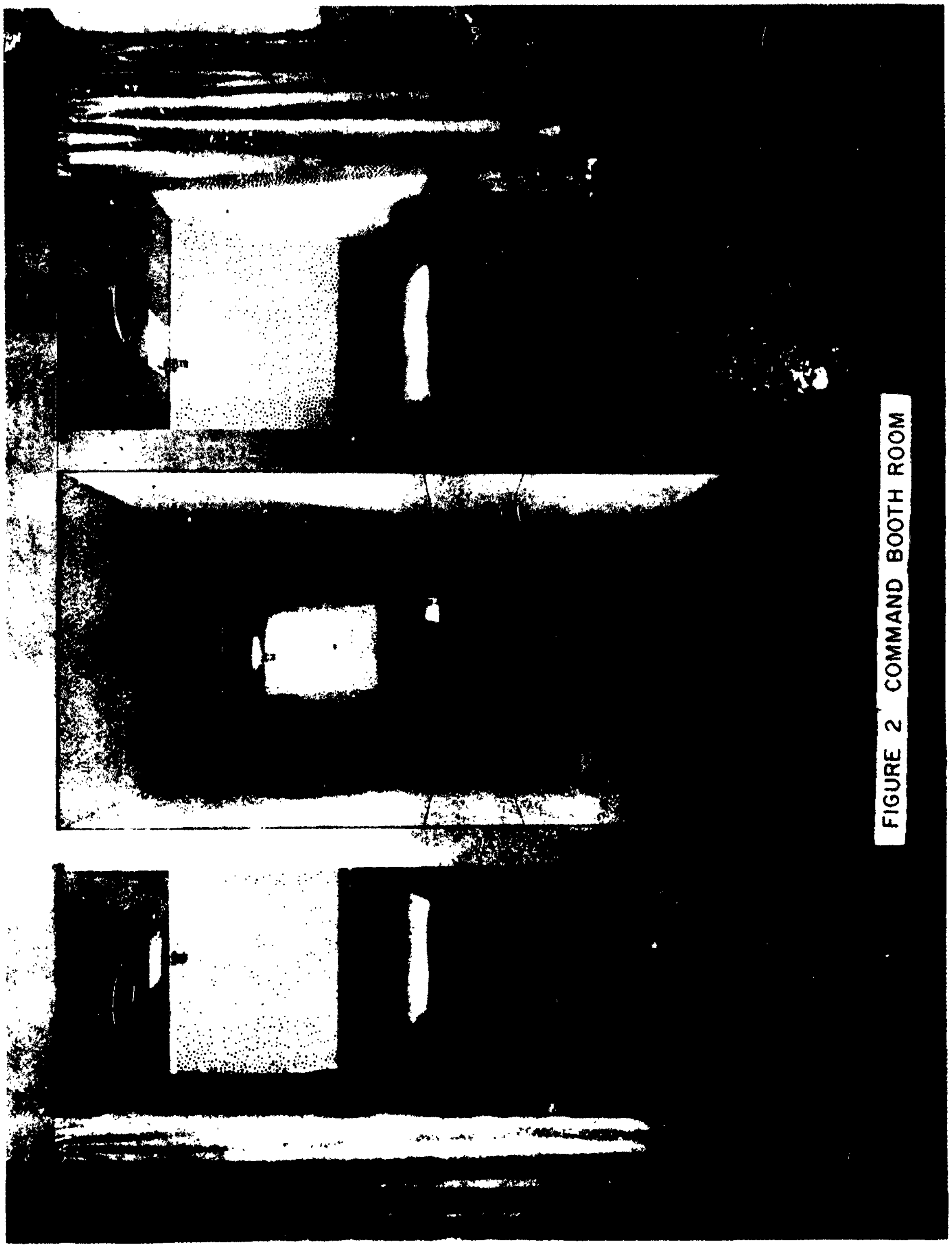


FIGURE 2 COMMAND BOOTH ROOM

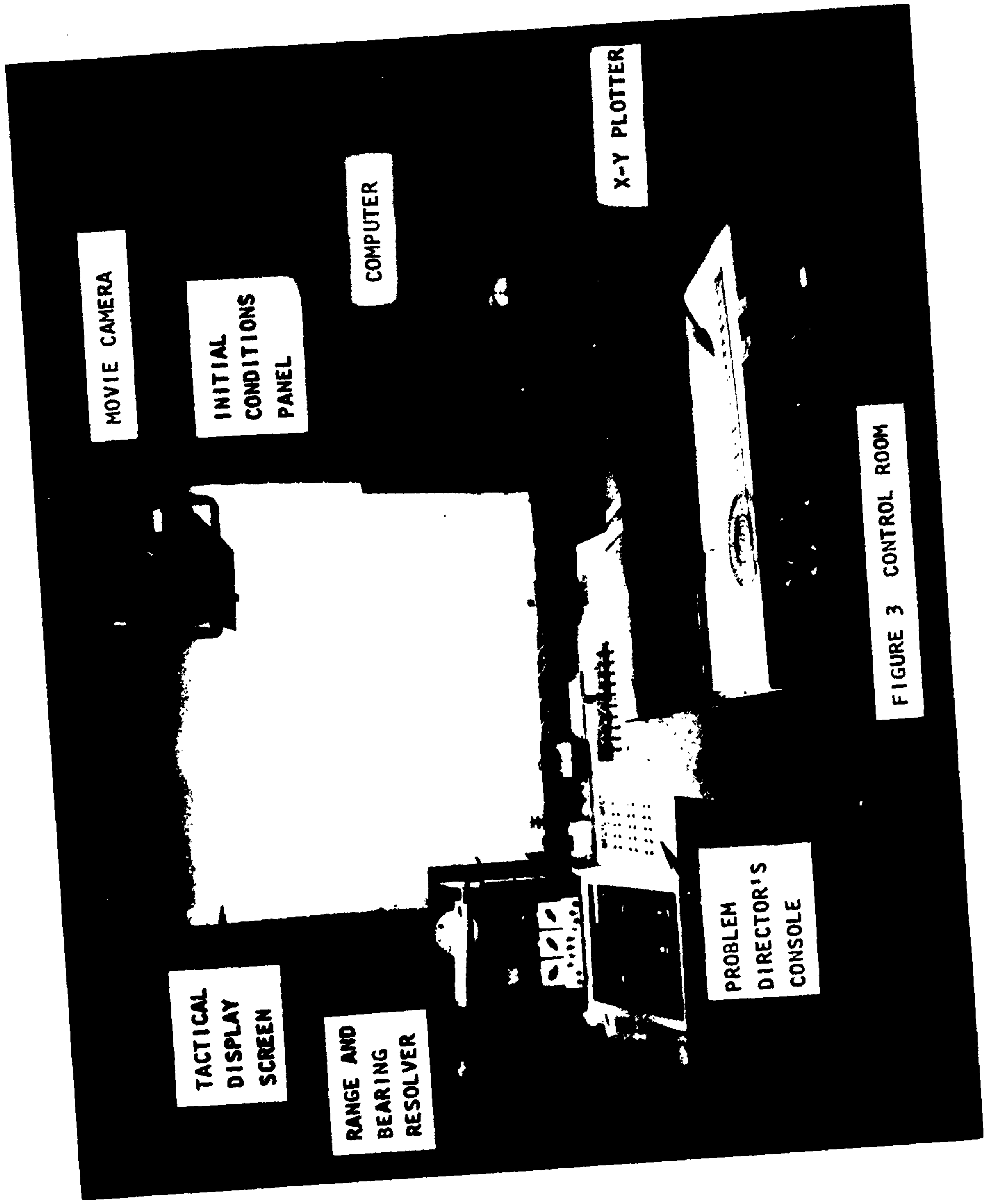


FIGURE 3 CONTROL ROOM

simulation are also located in this area. Signal flow between the subjects, experimenters and the equipment is shown schematically in Figure 4.

As I mentioned earlier, the command booth area is composed of five identical, but isolated booths. Each booth contains a console which includes a plotter and plot generation equipment, a control and display panel, and a communications system (Figure 5).

The facility is designed to permit the experimental manipulation of a number of independent situational variables (Figure 5a) which include, but are not limited to:

(1) Vehicle number and type
(2) Communications
(3) Time scale
(4) Environmental characteristics
(5) Detection capabilities
(6) Weapon capabilities
(7) Pre-programming

(1) Vehicle number and type

Five vehicles or groups of vehicles can be simulated dynamically within the facility. These can represent: ships, aircraft, helicopters, land vehicles, missiles, mobile radar, direction finding stations or other vehicles or stations. Vehicles or objects that do not require dynamic control may be "played", i.e. represented in their outputs, by the experimenters.

(2) Communications

Experimental control of communications permits a means whereby information transmission can be manipulated. Verbal communications can be effected in any combination from subject to subject and from subject to experimenter. The "security" of communications can be controlled

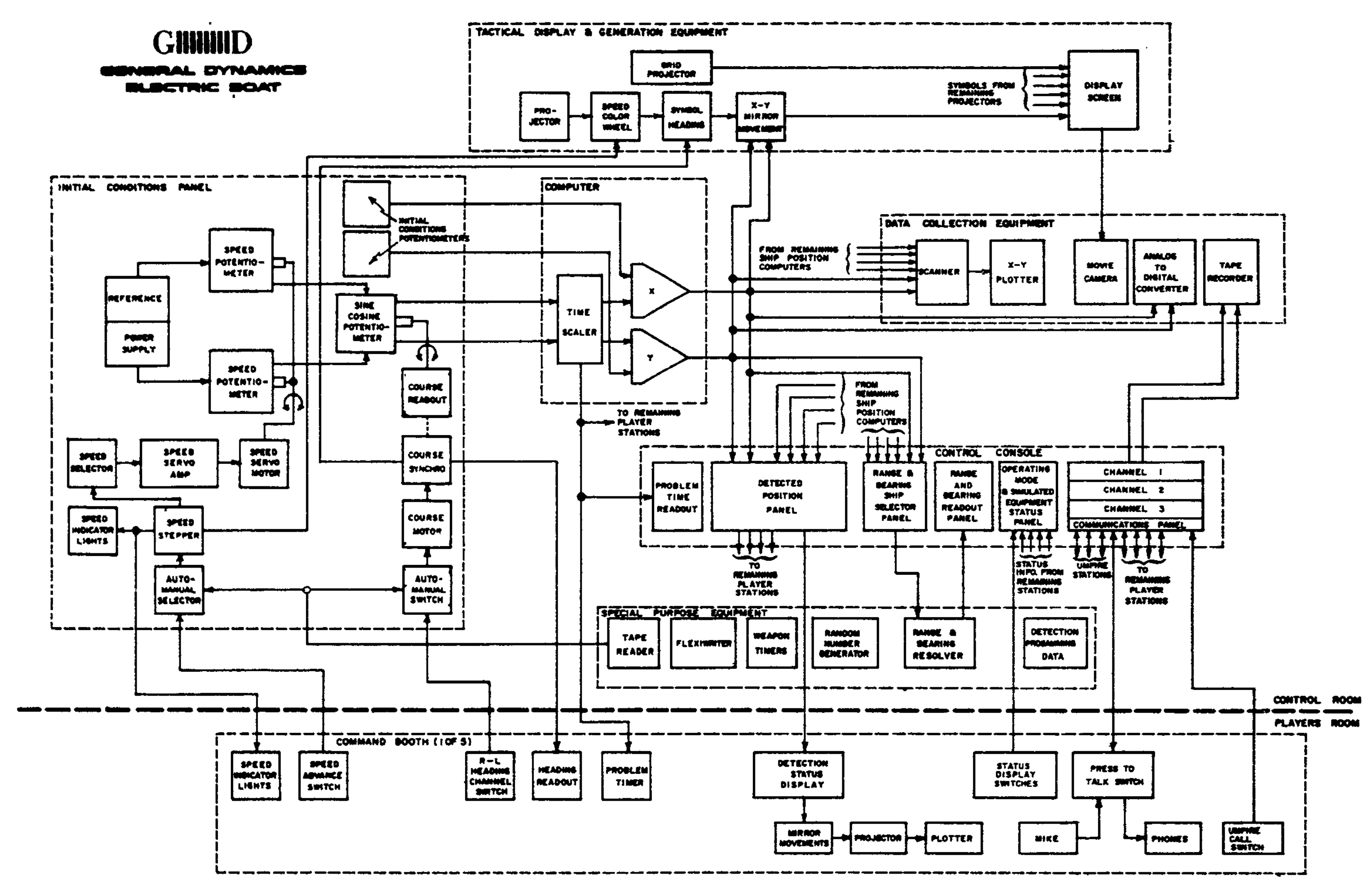


Figure 4 SUBTAG SYSTEM BLOCK DIAGRAM

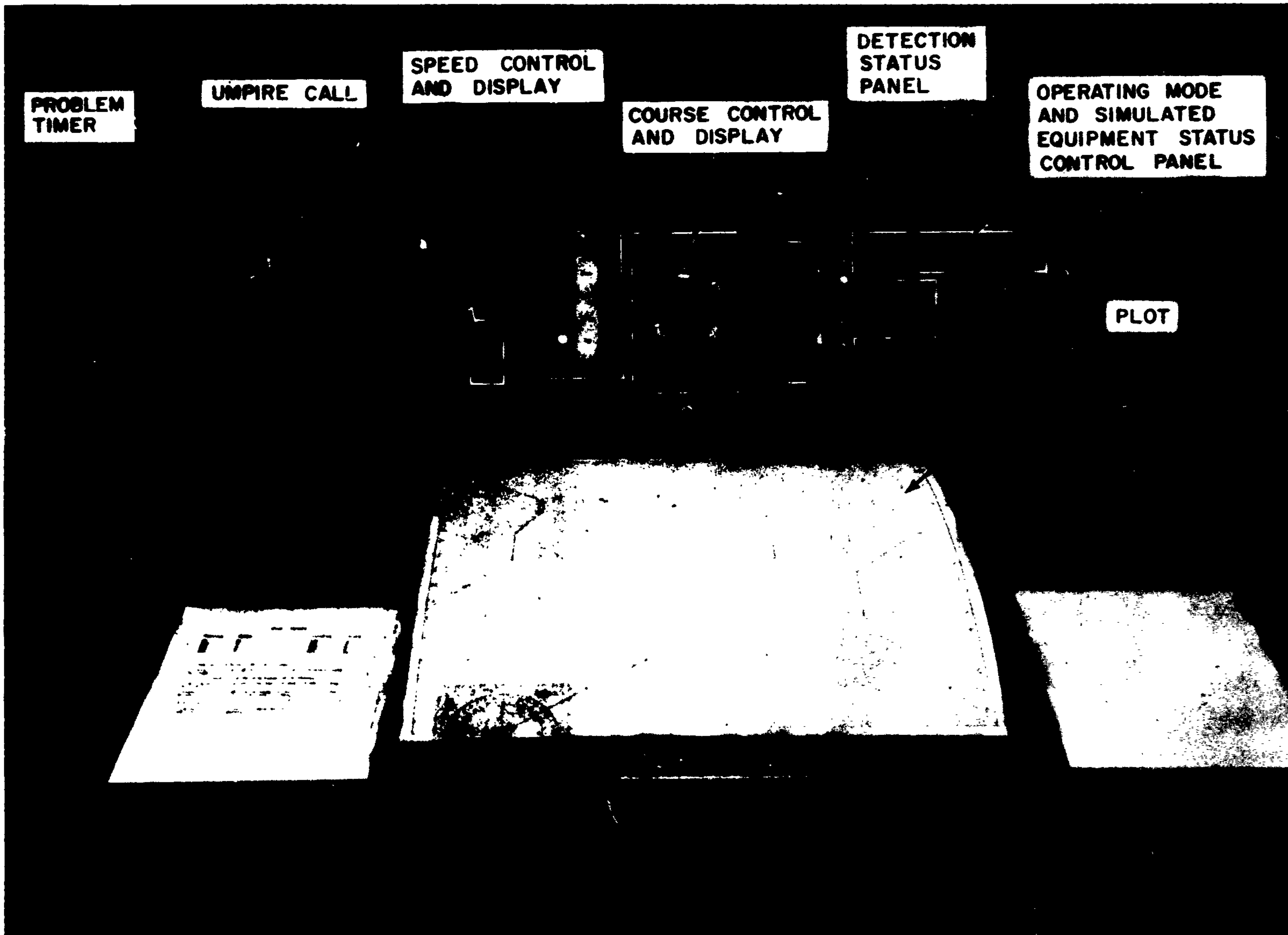


Figure 5: Command Booth Console

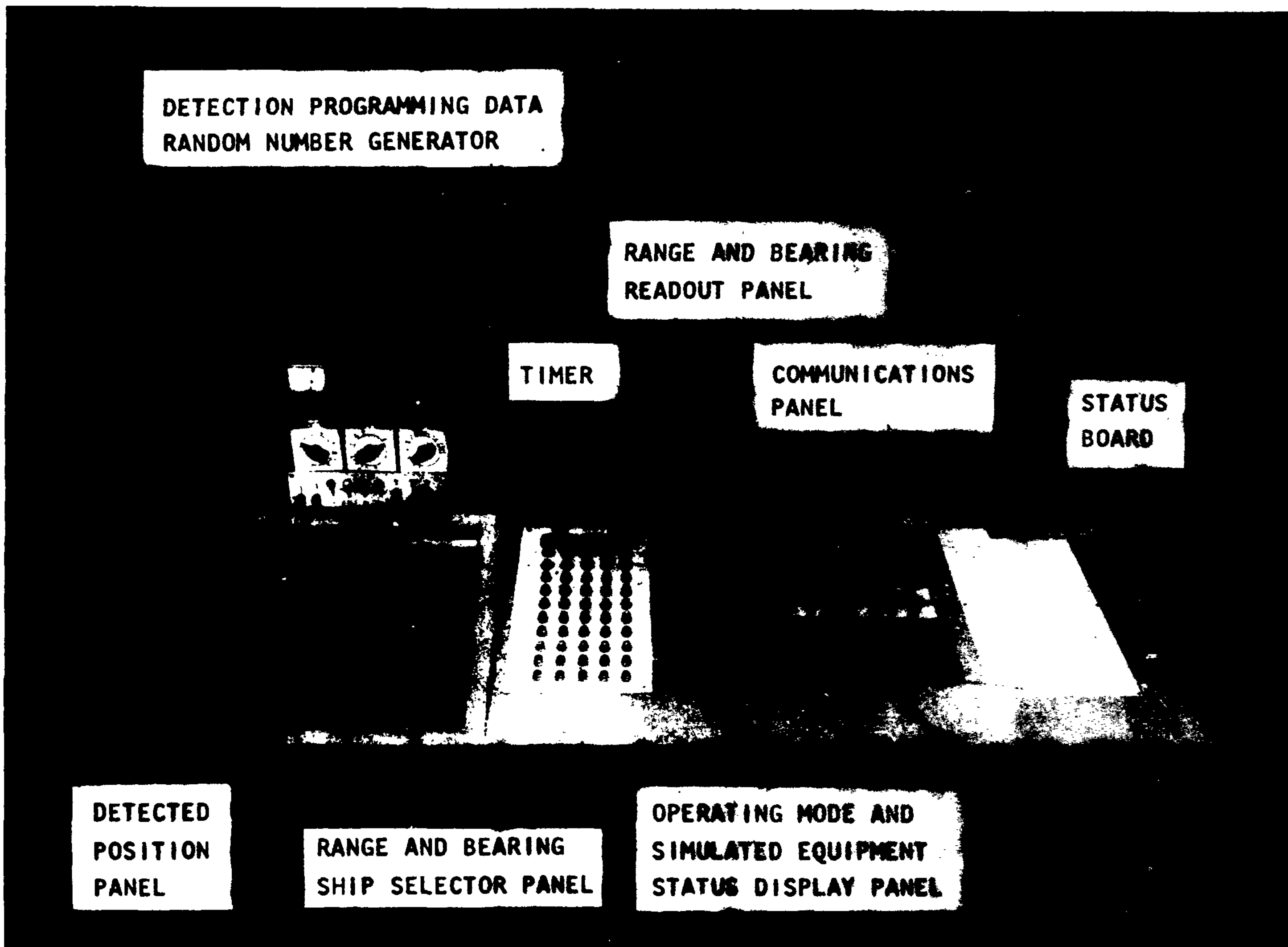


Figure 5a: Problem Director's Console

as can the detectability, length of transmission, and other operational constraints. A two channel tape recorder provides complete communication data collection.

(3) Time scale

Experimental decision-making situations can be presented under real-time or various levels of slow or accelerated-time conditions. This capability makes it possible to determine the effects of the relative speed with which events occur (all other factors being held constant) in order to establish the significance this variable may have in training situations. It is obvious that if the time scale can be accelerated appreciably, a great savings in training time will result. However, this savings will only result if it is empirically established that decision-making behavior does not differ qualitatively as a result of variations in time scale.

(4) Environmental characteristics

Among environmental parameters that can be manipulated as independent variables are sea state, land cover, atmospheric conditions, bathythermographic conditions, etc. Moreover, characteristics of geographical stimulus configurations can be represented. Land masses, underwater obstacles, and topographical features may be varied independently. Considerable variation in the geographic scale is possible; the distance represented by a side may range from 10 to 500 miles, for example.

(5) Detection capabilities of vehicles

Detection capability cannot be considered strictly as an independent variable since it is itself influenced by environmental conditions such as those mentioned above. However, types of detection equipment available may be varied, and, within the constraints imposed by the environment, potential capabilities may be specified. Outputs from gear such as radar, sonar, ECM, MAD, and periscope, as well as from unaided visual systems can be presented to subjects.

(6) Weapon capabilities of vehicles

The number, type, range, and speed characteristics of weapons available can be varied by the experimenter although actual selection and employment of weapons is determined by the subject. The subject receives information concerning his capabilities from verbal communications occuring prior to the problem. He selects weapons and provides parameters relevant to their firing via the communications network and is informed of the results of his actions by the same means. Weapons which can be employed include: torpedoes, hedgehogs, depth charges, bombs, missiles, anti-aircraft fire, mines, etc.

(7) Pre-programming

The facility provides the capability for pre-programming the actions of any number of the dynamic operator stations by means of a Flexowriter punch tape and five tape readers connected to the input channels of the five stations. This capability permits the presentation of identical complex tactical situations to several different individuals, or, if desired, to the same individual on different occasions. A means is thus available to reduce both experimenter error to a minimum and to provide a completely controlled basis for establishing the stability of operator responses to various situational parameters.

In another vein, the SUBTAG facility provides a means for research on an additional facet of training for decision-making. There are several levels of simulation abstraction which can be derived from the usage of the facility. The most obvious is the utilization of the facility to achieve the maximum possible correspondence to the actual military system. While SUBTAG does not simulate the actual physical environment of the decision-maker (submarine control room, CIC, as examples), it does provide him with the information necessary and sufficient to accomplish a given mission. From this level of maximum "realism", it is possible to remove certain quali'ies of the simulation in order to evaluate the effects of the level of abstraction of the training situation upon decision making performance. For example, the dynamic movement can be removed and the attributes of the more abstract "maneuvering board" simulation can be effected and evaluated.

We have recently started the experimental portion of our research program. The initial series of studies is concerned with factors involved in decision-making of the Implementation type in the ACADIA schema. The essential task of the decision-maker is to "implement" a course of action (fire a weapon) as a function of (conditioned by) the momentary relationship between his own and an enemy's probability of success, both of which vary (increase monotonically) as a function of time.

The independent variables which will be manipulated systematically include:

(1) The time scale involved in the dynamic development of the situation

(2) The perceived (displayed) rate of change of relative probability of success of self and enemy

(3) The rate of motion of the enemy target(s)

(4) The number of targets under simultaneous surveillance

(5) Incorrect information

(6) Ambiguous information

The contextual background for this particular series of experiments is derived from the following considerations.

Many military decisions made in a confrontation of the enemy situations involve the choice of the "proper time" to implement some known, specifiable course of action. As examples, a weapons direction officer must decide the "proper time" to fire a missile at an approaching enemy aircraft, a S/M skipper must decide on the proper time to fire a torpedo or to take a significant tactical action such as active pinging, etc. These situations involve basically a conflict between two opposing requirements involved in the consequences of military engagements which are to (1) destroy the enemy, and (2) prevent the enemy from destroying oneself or achieving his goal. From the moment a contact with an enemy is established a dynamic process begins such that the decision maker permits the situation to develop over time to the point where an available course of action will have a complete or maximum chance of accomplishing the mission. The reasons for permitting time to pass may be (1) to permit the accumulation of more and/or more precise data regarding the target, and (2) to permit the effective range to decrease (assuming that a weapon or ping is more effective as range is reduced, etc.). Thus, if the D-M* allows more time to pass he increases the probability of success of the prescribed course of action. Ideally, the D-M would allow the situation to progress to the point where 100% success was assured, i.e. fire a

* D-M stands for Decision-Maker

torpedo at 100 yds. However, the situation rarely permits this course of action. Except in an ideally executed and completely successful ambush, the D-M is normally faced with the fact that as the situation progresses the probability of success of the enemy in detecting, localizing, and destroying him also increases. The rate at which the enemy's chances of success and the D-M's chance of success increase are not necessarily equal and opposite as a function of time, do not vary linearly with time, and do not vary in the same manner from encounter to encounter. Thus, the D-M is faced with a dynamic situation which forces him to make a decision with regard to the "proper time" to execute some course of action which maximizes his chance of success and minimizes the enemy's chance of success.

The situation may be described abstractly in the following manner using a spatially varying situation. The D-M detects the presence of an enemy; at the moment of detection the probability of success is zero or very low (if not 0 or low no decision is involved - reponse would be automatic if 100%). Assume a situation in which the probability of own success increases monotonically with time (this is true in an AAW barrier - not necessarily true with an opening target in S/M ASW). The probability of success would increase as a function of a variety of causes such as increased reliability of kill as a function of target range, more precise localization of target, more effective weapon preparation, etc. However, the effects of all of these factors can be expressed as a change in probability of success over a single dimension---time. Similarly, the ability of the enemy to destroy the D-M can be expressed as a function of time. In a military decision-making situation the probability of own success rarely reaches 100 before the enemy's chance of success reaches a value above zero. (If it did, no decision would be involved). Thus, the D-M is faced with the dilemma of having his own chance of success increase to as high a value as possible before the enemy's chance of success rises to too large a value. The situation can be represented graphically, thus

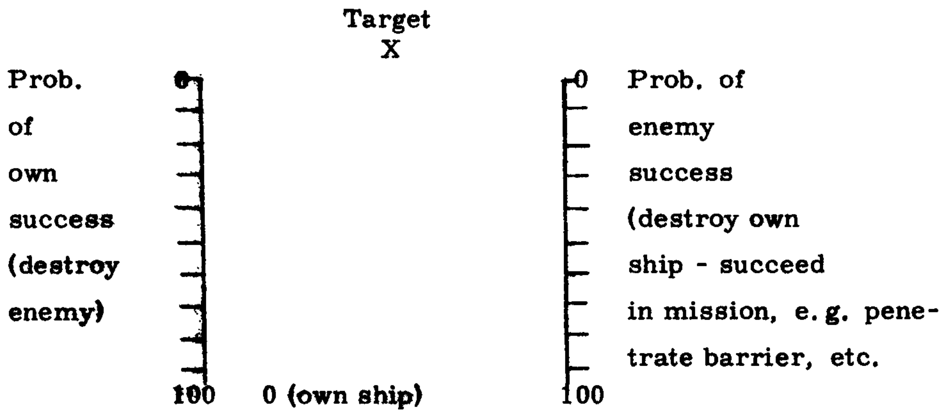


Figure 6

The essential elements of this situation are:

own ship location

target location

range to target

probability of own success (as f of a given and/or required course of action)

probability of enemy success
change in above probabilities as f of time

The D-M's task is to select the optimum combination of own success vs. enemy success probability (which occurs at some point in time between time 0, zero (initial detection) to time C (100% probability of success of either self or enemy)).

The purpose of the projected experimentation is not to determine how accurately D-M can establish the optimum game theory tactic, i.e. mathematically optimum solution or trade-off, but rather to obtain data about how various characteristics of this situation affect the D-M's behavior. For example, it is possible to maintain all of the factors involved in Figure 6 above constant except for the rate at which the target progresses from Time 0 to Time C.

This would permit one to determine whether D-M's make the same decision, i.e. are consistent in selecting a "proper time" in different military situations such as AAW and S/M ASW which vary essentially only in the rate at which relative closure occurs. Information regarding this characteristic of human behavior would have significant implications for training device and procedure design since, if it could be shown the D-M's do behave consistently independent of time scale, then it would be possible to train decision-making skills in a limited training situation with assurance that the D-M training would be generalized to the specific situations they would face in their respective duties, e.g. Weapons Control Officer, S/M C.O., etc.

It is submitted that there are tactical situations in which the decision maker (e.g. weapons control officer) does proceed on the basis of such a scale which is a composite of the many factors which enter into the tactical situation. The more skillful he is, the more of these factors he can incorporate into his "probability scale" and the greater the correspondence between the changes in his subjective probability and the objective probability associated with these variables. Now the subjective scale developed by the decision maker is unique to each confrontation, i.e. target, because each target has at least some unique characteristic associated with it (for example, if two successive targets appear which are identical in all other respects, speed range. bearing weapons, etc. they are each unique since the response to #2 is conditioned by the success or failure of the response to #1). The point here is that although it might be possible, in theory, to specify the physical correlates of most of the factors which affect the nature and form of the probability of success scale, in practice thus would be very difficult if not impossible. However, for purposes of the present experiment, the specific characteristics affecting the form of the scale are essentially irrelevant since the object is to determine characteristics of the subjects responses to a given scale (obtained in a "meaningful" context) as a result of experimentally manipulated situational characteristics. In other words, data regarding the nature rather than correctness of the subjects' behavior is the object of the study.

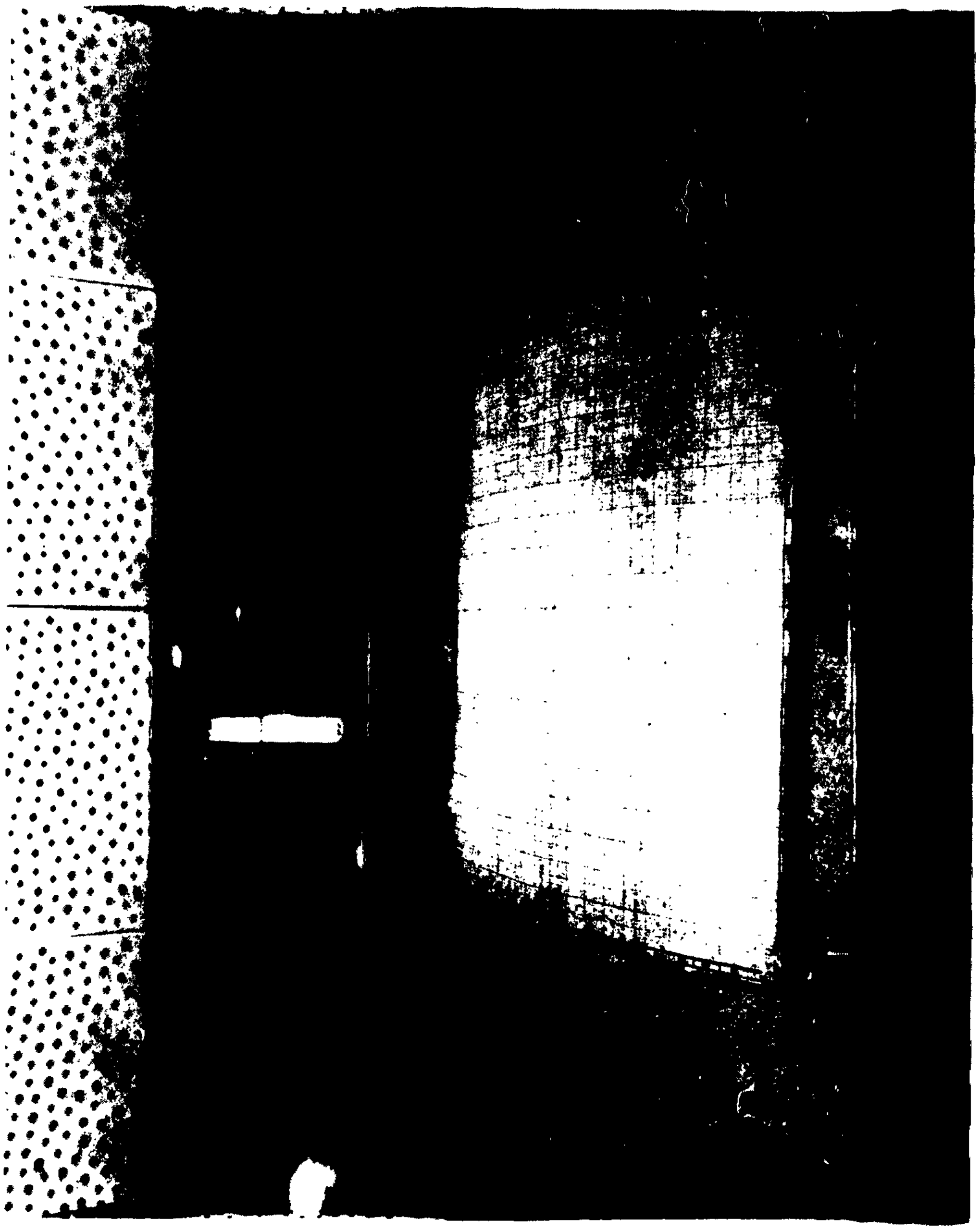
The SUBTAG facility was employed for this first study. Each of the two booths used contained a large X-Y display upon which a moving target (pip of light) was presented. On either side of the X-Y display, digital readouts indicate the momentary probability of success of "own ship" (left readout) or of the "enemy" (right readout). The experimental set-up is shown in Figure 7.

Own and enemy probabilities increased during the course of the trial at one of 6 different rates as shown in Figure 8.

The expression of the rate as 10/5, for example, indicates that 100% probability of success was reached in 50 units of time (100 units of time equalled 60 seconds). There was a systematic change in the rate comparisons from 10/5 vs. 10/10 to 10/10 vs. 10/10. In one-half of the experimental trials (22 in all), own unit possessed the rate advantage, and in the other half, the enemy unit had the rate advantage. There were, in addition, eighteen masking trials in which there was no consistent advantage for either own or enemy unit, and five warm-up trials.

Figure 7

SUBTAG Booth Showing Subject's Display



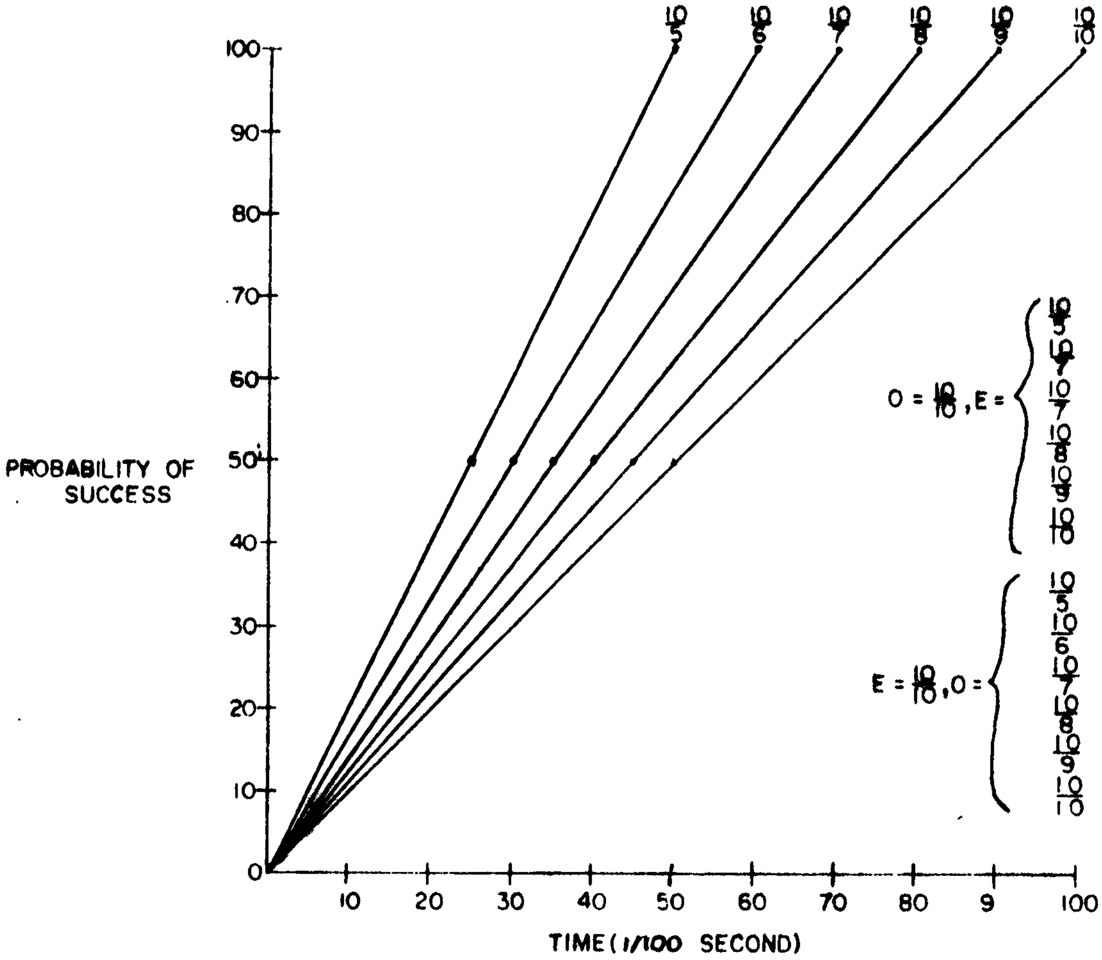


Figure 8

Rate of Change of Probability as a Function of Time

Feedback was given after each trial. The subject was told he had scored a hit or had missed. Hits were determined on the basis of the comparison of a randomly generated number with the probability (own) present at time of firing. Mutual hits were not allowed. The subject was not told the time at which the enemy fired.

Analysis of the data in this preliminary experiment resulted in the observation that the subjects fired at certain particular combinations of own / enemy probabilities, i.e. their behavior is extremely stereotyped and predictable particularly when own unit had the advantage. A slightly greater amount of variability occurred when the advantage was with the enemy.

Some of the additional results are presented in Figs. 9, 10, 11, and 12. Figure 9 (means of data from three Ss) indicates that firing time selected (expressed in terms of own probability of success) decreased as the ratio of own to enemy probability of success decreased from 2 to 1 (0 = 10/5, E = 10/10) to 1 to 2 (0 = 10/10, E = 10/5). It also suggests that while the shape of the curve was consistent over the 4 days on which data were collected, the level of firing times differed from the first two to the second two days, firing on the second two occuring consistently earlier.

Figs. 10 and 11 present the data from three individuals, plotted with the same X and Y units. A comparison of the two figures indicates that variability increased markedly during the last two days, both within the subject's responses across the series of experimental values, and among subjects with respect to their level or range of responses.

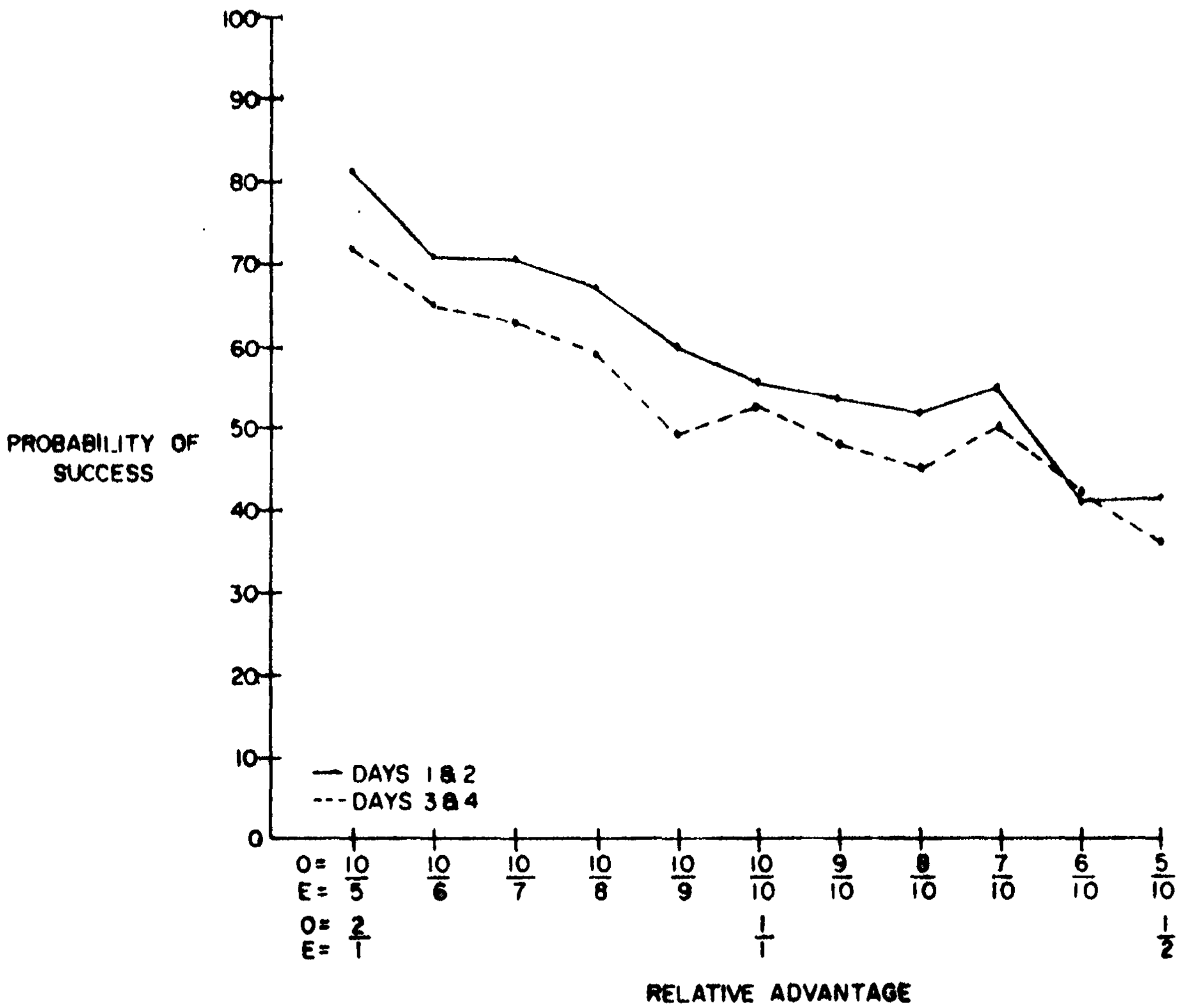


Figure 9

Mean Probability of Success at Time of Firing as a Function of the Ratio of "Own" to "Enemy" Advantage

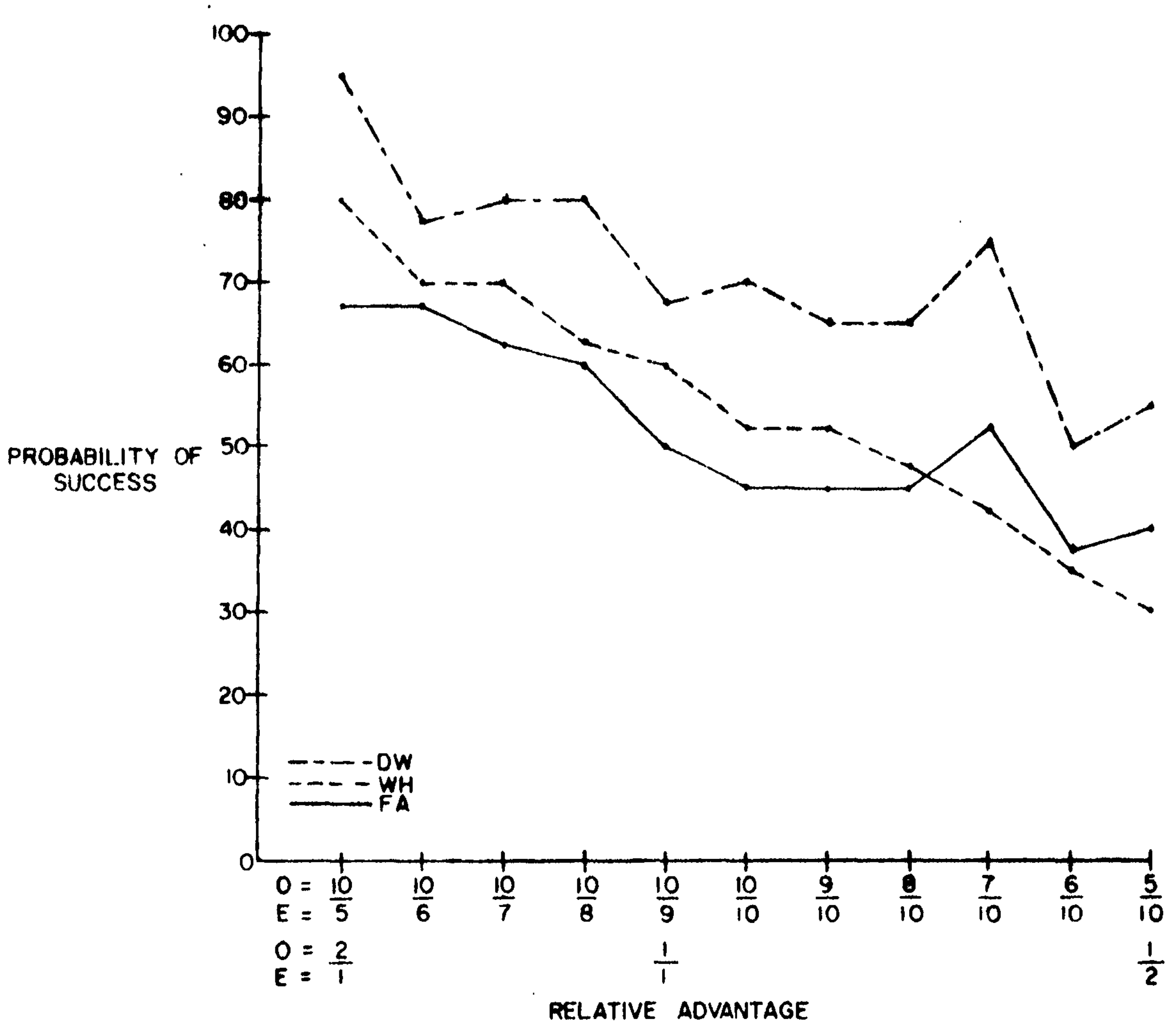


Figure 10

Probability of Success at Time of Firing for Individuals as a Function of the Ratio of "Own" to "Enemy" Advantage (Mean of First Two Days' Data)

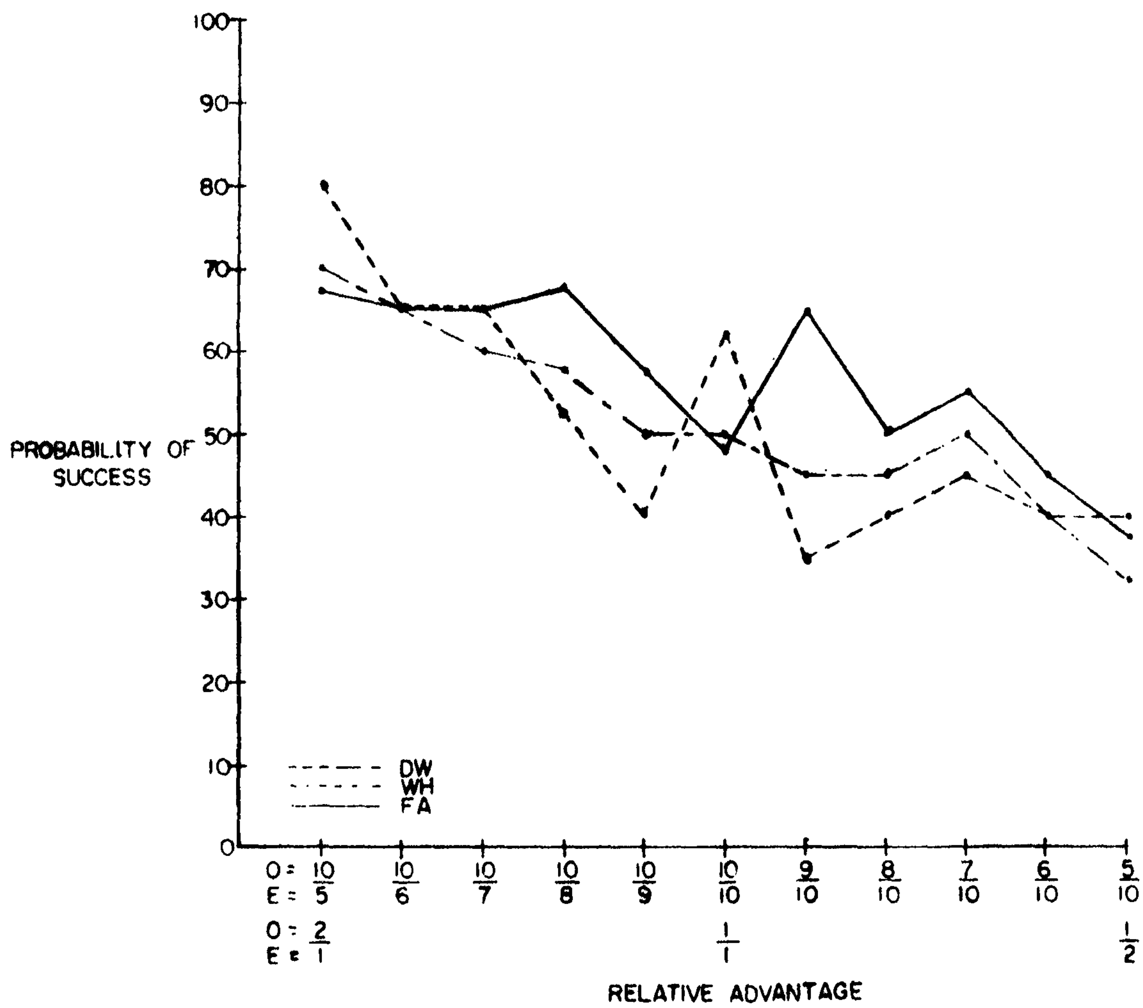


Figure 11

Probability of Success at Time of Firing for Individuals as a Function of the Ratio of "Own" to "Enemy" Advantage (Mean of Second Two Days' Data)

Fig. 12 shows a comparison of mean own unit probability of success at time of firing and enemy probability of success when enemy had comparable advantage. The enemy datum points are calculated and they represent the answer to the question: In the situation wherein the enemy unit had the advantage, what was the enemy's probability of success when own unit fired? Or, in the 2 to 1 advantage situation, for instance, how high did the subject allow the enemy's probability of success to rise (when E had the advantage) in comparison to the height he allowed his own to rise before firing in the situation in which the same relative advantage was in his favor?

The data suggest that in general the subjects respond inappropriately in situations where the enemy has an advantage. Specifically, they generally tended to "fire" (in situations in which the enemy had an advantage) at a point just after the enemy had fired (as measured by their own response in the complementary situation). The outcome of this response pattern in the long run would insure maximum loss to self.

The technique developed in the above experiment has significant methodological implications for decision making research if further analysis and experimentation substantiates its validity. It will be noted that the procedure permits an evaluation of the subject's performance against an opponent (himself) whose characteristics (i.e. strategy and/or tactics) are empirically observable. This makes it possible to circumvent one of the fundamental difficulties inherent in Game Theory or other mathematical approaches to decision making research, viz, the use of Game Theory as a normative model implies that the application of a given player's "optimum strategy" represents his most rational mode of behavior. Actually, the use of an "optimum strategy" is rational only if the decision maker knows or perceives the enemy as more clever or more knowledgeable than himself. If the decision maker perceives the enemy as less "clever" or less "lucky" than himself the use of the mathematical "optimum strategy" is actually irrational since, if he is able to outwit the enemy the decision maker

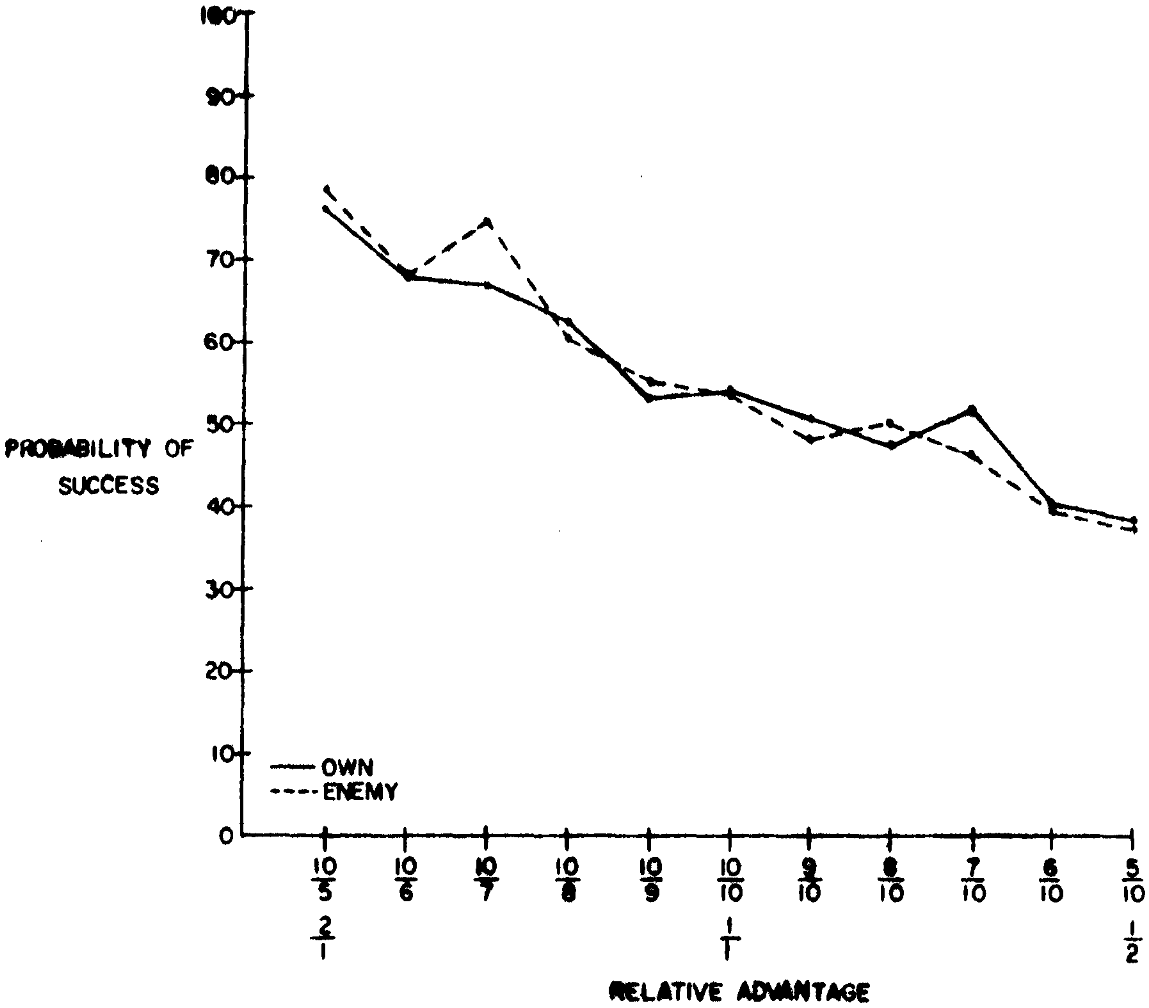


Figure 12

Comparison of Mean Probability of Success at Time of Firing for "Own Ship" and "Enemy" can gain more than the "optimum strategy" would permit. The problem for the experimenter has always been to specify the characteristics of the enemy, a problem which has usually been resolved by use of a "rational" mathematical model to describe the enemy's response characteristics. However, the fact is that in most, if not all military situations, the decision maker is opposed by a real person rather than a mathematical model. This real-person enemy does not act like a mathematical model and the decision maker knows it. The problem for the experimenter now is to evaluate the adequacy of an "irrational" decision maker vis-a-vis an "irrational" opponent. The technique developed in the present experiment permits the evaluation of the adequacy of the decision maker's response using the decision maker's performance itself as the criterion. The implications of this methodology will be explored further during the course of this project.

Effects of Structural and Environmental Variables on AAWI Decision Making

H.M. Schroder

and

S. Streufert

Princeton University

Introduction: The Components of Information Processing

Decisions - no matter how complex or simple - can be described as responses of the decision making organism to environmental or internal stimulation. What kind of response will occur depends to a large degree on (a) the particular constellation of stimuli impinging on the organism, (b) the information previously amassed by the organism (effects of training), (c) the directionality and magnitude of the organism's behavioral orientation (personality or behavior content variables) and (d) on the organization of the organism's information processing components (variables concerned with the structure of the organism). Most action decisions will probably be a function of some interaction of all four determinants. A great number of psychological investigations have been concerned with determinants (b) and (c). Only few investigations have been concerned with the effects of determinants (a) and (d), particularly as they interact to produce decision making behavior. The plans for the research discussed in this paper include an attempt to analyse, describe and predict the outcome of the interaction of all four determinants, with special emphasis on the effects of environmental (input) and structural variables.

Results of past experimentation with these variables makes it appear highly probable that the quality of information processing and consequently the quality of decision making can be greatly improved by a coordinated manipulation of the above determinants. At the Group and Environment Design Laboratories at the Psychology Department of Princeton University information processing and decision making is studied in a number of simulated environments. One of these will be a simulation of some of the aspects of the anti air warfare environment. It is hoped that the analysis of the components of information processing in this environment will be an aid towards the improvement of individual and group performance in that situation.

Characteristics of the AAWF Environment:

The decision maker in the anti air warfare situation is required to concern himself with a number of tasks. At the initiation of the battle he is not aware of the strategy that the enemy will employ. Consequently he must attempt to construct for himself the environment of the opponent. This environment should permit certain moves by the enemy, but not others. The decision maker must be aware of the feasible potential strategies the enemy might employ at any particular time, so that the best defensive response can be made.

One of the decision areas concerns the attempt to elicit informational feedback from the enemy. For instance, information may be gained about the location of an enemy by turning on radar, but at the same time information about the fleet location is given to the enemy who is able to pick up the radar signal. Certain environmental conditions would favor the radar "information search" response, others would not.

As information about enemy moves becomes available to the decision maker, he must organize this information to gain the maximal possible insight into the potential strategy of the enemy. In other words, he must make a set of hypotheses about the moves of the opponent. These hypotheses should be subject to change as further relevant information becomes available. Once such hypotheses have been made, they should be checked for applicability. Such a check can be made in at least two ways: (1) by observing the changing environment for any event that is inconsistent with the hypotheses, and (2) by acting on the environment in an attempt to gain further relevant information.

Once the hypotheses have been made, the AAWF forces of the fleet must be deployed in such a way that optimal success probability is assured. The organization of these forces should remain flexible to a degree, so that changes can be made if necessary as a consequence of alterations in the environment or new insights into enemy strategy.

In more general terms we may describe the AAWF environment as emergent, as having many degrees of freedom, such that no fixed set of operating procedures can be specified for effective performance over different runs. Information load, the complexity of the available information, and noxity (stressing aspects) are high. These factors are increased by the limitations imposed upon the decision maker by the physical capacity of the available equipment.

Characteristics of Decision Making in the AAWF Environment

1. The Design of a Simpler Decision Making Environment

A simpler war simulation was designed at the laboratories at Princeton University to measure the effects of personality content, personality structure, group structure, information load and other variables on the quality of decision making by participants in the simulation. Subjects (decision makers) were presented with a map of a fictional island supposedly occupied by an enemy. The task was to remove the enemy from the island. Resources, locations of resources and their capacities were given only for the armed forces of the subjects. Similar information about the enemy was not available. So far, groups of four decision makers per simulation have been used. Information about enemy moves was available only when observation of the enemy by the forces of the subjects was possible, or when the subjects (decision m[illegible]rs) had in some fashion provided for an observation of certain enemy moves.

2. Experimental Variation in the War Game Simulation

So far only a few of the potential variables affecting information processing in this simple war game simulation have been explored. Additional experiments are now in preparation. Differences in the quality of decision making have been found on the basis of differences in environmental complexity, in personality structure of the decision makers, and in the stressing aspects of the environment. The first two of these variables will be discussed below:

(a) Experimental variation of environmental complexity

A number of previous experiments (e.g., Driver, 1962; Tuckman, 1963) had shown that decision making in such tasks as an inter nation simulation and a stock market game consistently varies as a function of the complexity of the simulated environment. Both above and below optimal levels of environmental complexity appeared to depress the quality of information processing. To establish whether a curvilinear relationship of environmental complexity to quality of information processing would hold, decision makers in this simple war game were exposed to a simulated environment which varied greatly over time in the richness of available information. The simplest form of variation in information complexity was used: differing number of information units fed to the subjects per time unit. Quality of decision making was measured in terms of the integration of the decisions into meaningful and purposive strategies. For example, any isolated move which was unrelated to any other move in past or future and which could be seen as constituting a part of a transcending purpose received a high score. In other words, decision makers who responded to the environment by integrating informational feedback from diverse sources and across time, received high scores for the periods in which such strategies were employed. Decision makers who responded to the environment with retaliatory unrelated action decisions received low scores for periods in which only such retaliatory or isolated actions occurred. The U curve that had been suggested by the findings of Driver and Tuckman did clearly appear in the data analysis. Such a curve is shown in Fig. 1. The data represented in this graph are mean scores for six runs of the war game simulation. Information Load is plotted on the abcissa. The load varied from two inputs of information per half-hour period to 40 inputs per half-hour period. Optimal decision-making quality (highest degree of differentiation and integration involved) was achieved for information loads of ten inputs per half-hour period. Both very low information load (two inputs per half-hour period), and very high information load (40 inputs per half-hour period) resulted in simpler, less effective decision making in all groups. We can see from previous experiments, and from this experiment involving a simpler war game simulation, that information load should be optimal in order to produce optimal decision making. This finding may well have important implications in the AAWF environment.

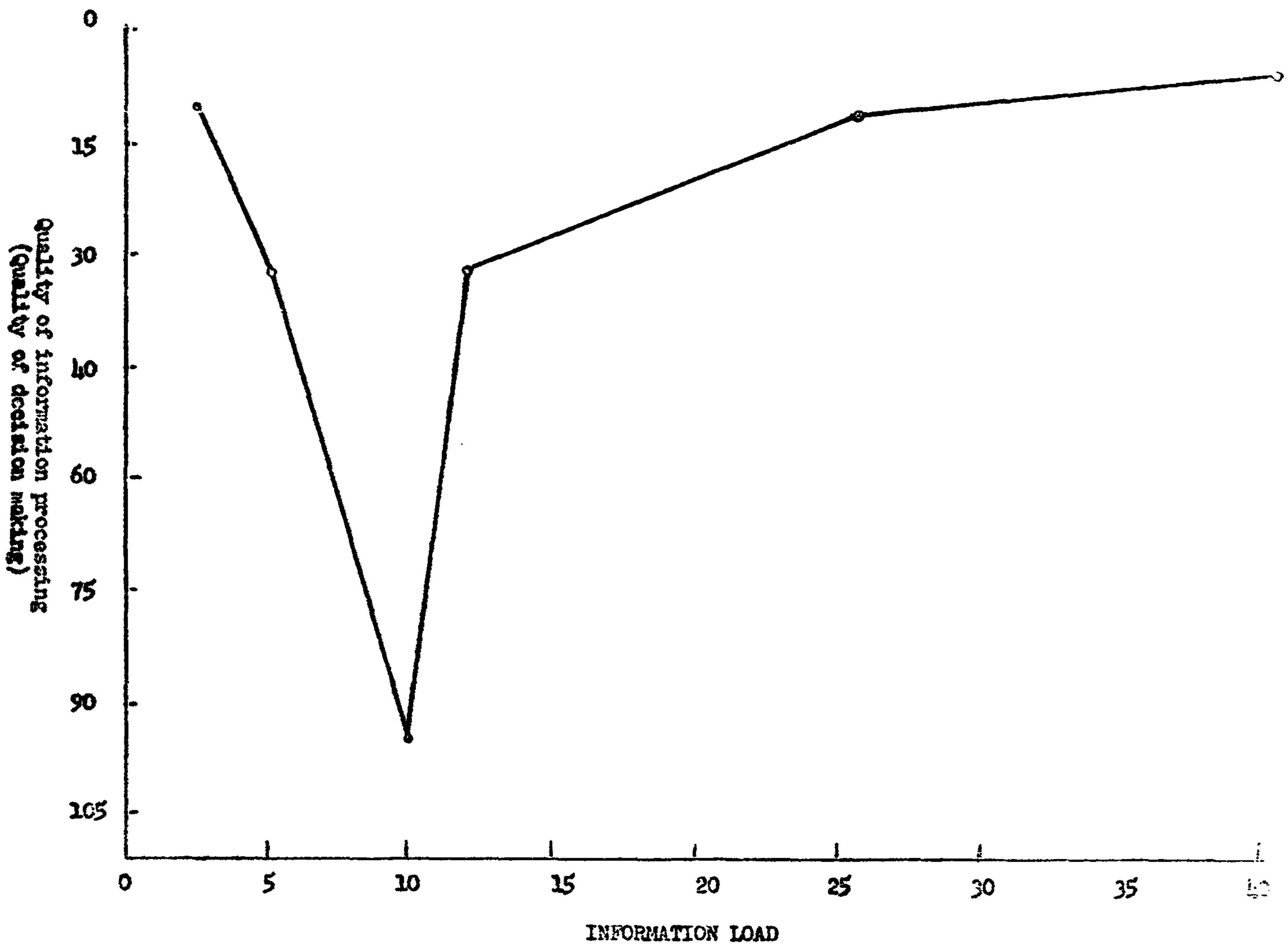


Figure 1. Quality of information processing as a function of information load (For six teams varying in integrative complexity).

(b) Experimental variation of personality structure

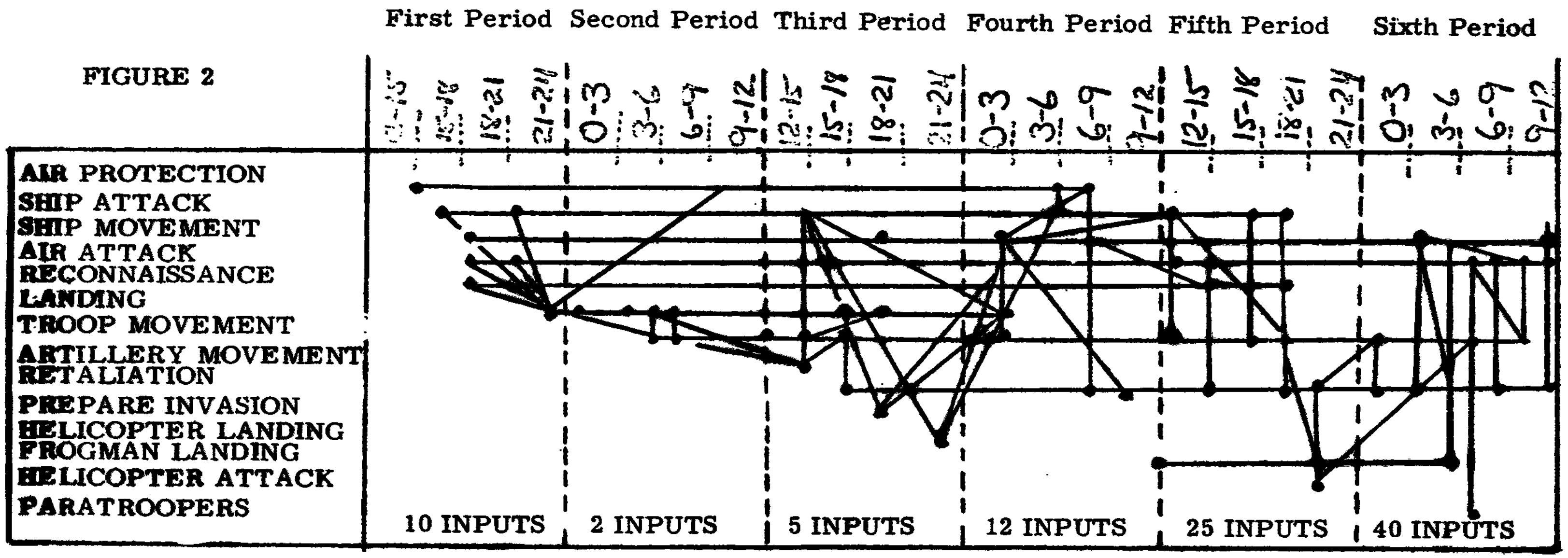
Harvey, Hunt and Schroder (1961) and Schroder, Driver and Streufert (1963) have proposed conceptual structures as determining the information processing characteristics of organisms. Such organisms may be individual decision makers, or groups involved in a decision-making task. Their structure is measured in terms of the level of integrative complexity of information processing. Integrative complexity implies not merely the capacity to organize incoming information into the components of the environment (differentiation), and compare and combine these components into new readings of the environment as a basis of action decisions. It implies also flexibility of such readings. Consequently, an integratively complex system is able to adapt quickly to environmental changes without necessarily changing the readings of all environmental components. An integratively simple system is less adaptive, since either a change of such readings will not occur at all, once a reading has been established, or the entire system of readings may have to be changed.

A number of experiments have shown either lack of change in interpretation of the environment or extreme change with change in the environment for persons or groups described as integratively simple (cf., Streufert, 1962).

Integrative complexity of decision makers was varied in the simulated war game described above. Group members were selected to form homogeneous groups of integratively complex (abstract) and integratively simple (concrete) decision makers. Again information load was varied as described above. It was predicted that the quality of performance (the level of integration in decision making) would be low for both kinds of groups when environmental complexity is too high or too low. It was also predicted, that integratively complex persons would achieve a much higher level of performance than integratively simple persons when environmental complexity was optimal.

The findings of this experiment are in part demonstrated by Figures 2, 3, and 4. Figure 2 is a plot of decisions made by a group consisting of persons described as integratively complex. The decision made are listed vertically. Time is plotted horizontally. Any decision is allocated a point. A horizontal line connecting points shows repetition of similar decisions. A vertical line occurs whenever a number of decisions were made at the same time. Whenever a decision is meaningfully related to a previous or future decision (as described earlier) it is connected with that decision by a diagonal line. A diagonal, therefore, represents a single integration of action decisions. The more diagonals, the more integrations. The greater the number of diagonals which join at one and the same point, the more decisions represent more complex information processing. The longer one can follow diagonal connections from point to point etc., the greater

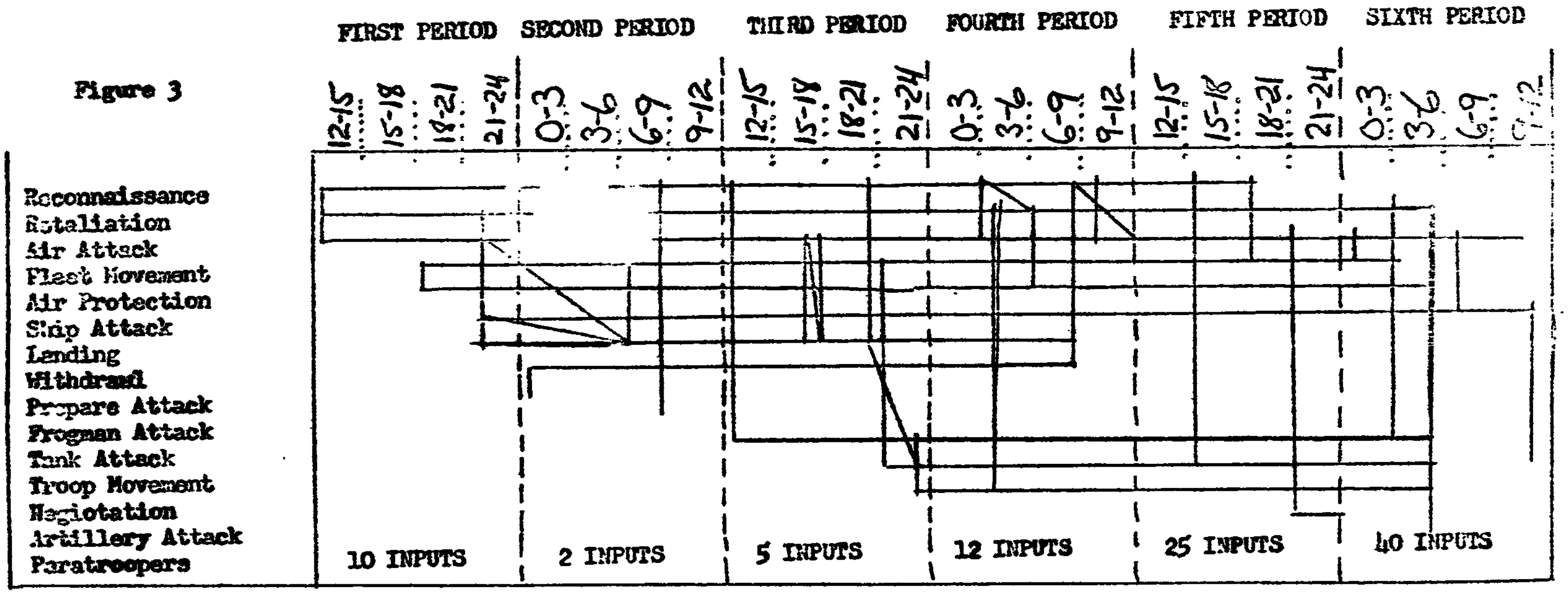
FIGURE 2



Each point represents a decision executed by the team.
Each diagonal represents the integration of feedback from an action and a new decision at a later date.

THE DIFFERENTIATION AND INTEGRATION OF ACTION DECISIONS
OVER TIME FOR AN INTEGRATIVELY COMPLEX TEAM

Figure 3



Each point represents a decision executed by the team

Each diagonal represents the integration of feedback from an action and a new decision at a later time

THE DIFFERENTIATION AND INTEGRATION OF ACTION DECISIONS
OVER TIME FOR AN INTEGRATIVELY SIMPLE TEAM

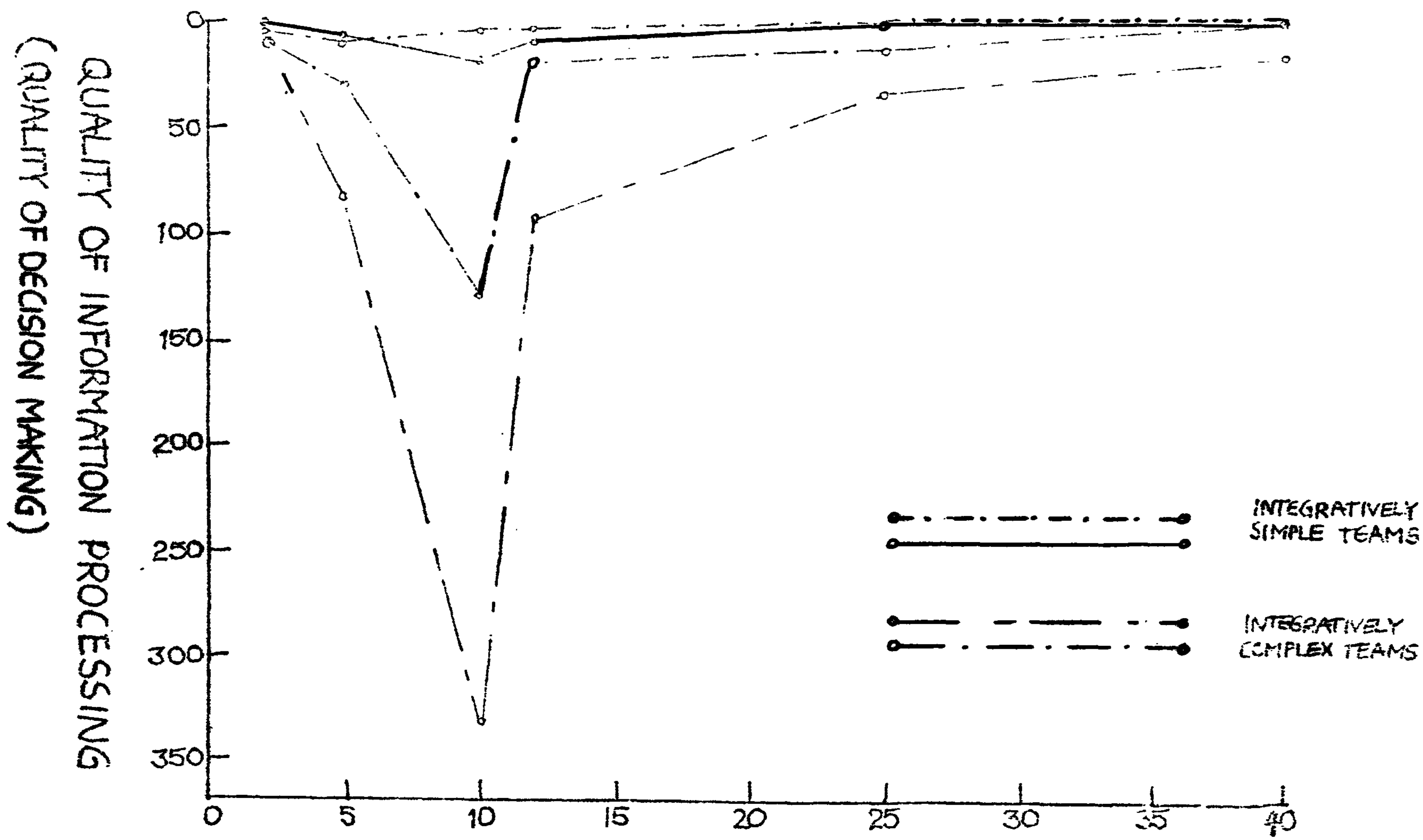


Figure 4

Information Load

Quality of Information Processing as a Function of Information Load the time span over which feedback is being utilized and integrated.

The various periods in the war game - separated in Figures 2 and 3 from each other by horizontal lines - represent periods varying in information load. The game was begun with 10 inputs per half hour, then 2 inputs, etc., in increasing order to 40 inputs.

Figure 3 is a plot of decisions made by a group consisting of persons described as integratively simple. Its construction is in all its aspects identical to the above discussed Figure 2. A comparison of the two plots shows clearly the difference in the number and pattern of diagonals (integrations) between the two groups of subjects. The group of decision makers described as integratively complex shows a much higher number of diagonals in game periods near optimal environmental complexity.

Again, as in Figure 1, we may plot the quality of decision making against information load. This has been done in Figure 4. We now have a set of U curves, two of these representing groups of decision makers described as integratively complex (abstract), two as integratively simple (concrete). The difference in the peaks of the two sets of curves is quite impressive. Groups consisting of abstract persons show a much higher level of performance to criterion for a point of optimal environmental complexity than do groups consisting of concrete persons. This difference is due in part to the emphasis on high level strategy in the determination of a score on the "quality of decision making" dimension. However, even if simply the number of integrations (number of diagonals per period in Figures 2 and 3) are plotted against information load, the differences between the groups is impressive. In no case do teams with concrete members outperform their abstract counterparts. Only in one case, as information load is extremely high (40 inputs per half-hour), do we find that a team of abstract persons drops to the performance level of their concrete counterparts.

Such findings, particularly in conjunction with similar results in a number of other experiments, point to the great importance of personality structure in determining performance levels in a complex task requiring flexibility in perception and performance.

Further runs of this war game with the above variables and other variables are now in progress. It is likely that further findings may shed even more light on the significant variables involved in the cognitive decision making process.

3. Decision Making Processes to be Studied in the AAWF Environment

The AAWF Environment will be studied primarily with an emphasis on the differentiation and integration involved in decision making. This analysis of differentiation and integration will take into account both variables of the environment (stimulus complexity, etc.), and variables concerned with the structure of the decision making organism (individual or group of decision makers). The first question to be asked in the research program is concerned with the determination of the necessity of differentiation and integration for optimum performance in the AAWF environment. Does an integratively complex organism outperform an integratively simple organism in that environment? If the task performance is not affected by structural variables, or if environmental stimulation is too highly overloaded, a consideration of such variables may have little utility. The second question investigated would be concerned with the environment itself: Can simulation from the environment be presented to the organism at an optimal level of complexity so that optimal performance can be expected? Finally we may raise the question whether some combination of integrative complexity of the organism and optimal complexity of the environmental stimulation can be determined to produce optimal decision making quality as required for the particular AAWF situation. Experiments, employing a simulated environment with many of the qualities of the AAWF situation will aim to determine how high level decision making can be facilitated. Such facilitation could be attempted in a number of ways:

(a) integration of feedback from the environment in an attempt to construct both own and enemy strategy may be facilitated by increasing or (more likely) reducing environmental input load to the optimum. This could be achieved through redesigning of displays which would then assist in information storage, assist in ease of information differentiation, and assist in ease of information integration;

(b) decision makers may be trained to maintain an optimal potential of integrative complexity in information processing. Limits would however be set by their respective optimal performance levels. The aim here would be to train individuals to be aware of (sensitized to) decrements in their decision making processes (due to information overload or stress), and to train these individuals to develop strategies for keeping environmental input optimal with minimal loss of information;

(c) attempts will be made to train decision makers to monitor the quality of their information processing and to initiate procedures (e.g., computer decisions) when the level falls below a given point;

(d) if possible, decision makers could be selected so that environmental complexity of the task matches their optimum performance level.

It is recognized that not all potentially proposed changes of the AAWF environment or personnel are feasible in all cases because of other Navy requirements. It should however be possible to introduce some changes that would lead to greater performance quality in the AAWF situation.

At the present time equipment is being installed at the Group Design Laboratory at Princeton to permit the simulation of the major aspects of the AAWF envi. nment. A number of runs of that simulation concerned with the variables discussed above are planned to be initiated as soon as installation is completed. It is hoped that some results will be available no later than the beginning of summer 1964.

Bibliography

(1) Driver, M. J. (1962) The Perception of Simulated Nations: A Multidimensional Analysis of Social Perception as Affected by Situational Stress and Characteristic Levels of Cognitive Complexity in Perceivers. ONR Technical Report #9.

(2) Harvey, O. J., Hunt, D. E., and Schroder, H. M. (1961) Conceptual Systems and Personality Organization. New York: John Wiley and Sons, Inc.

(3) Schroder, H. M., Driver, M. J., and Streufert, S. (1963) Information Processing Systems in Individuals and Groups. In preparation.

(4) Streufert, S. (1962) Attitude Generalization in Social Triads as a Function of Personality Structure and Availability of Social Support. ONR Technical Report #10.

(5) Tuckman, Bruce W. (1963) Personality Structure, Group Composition, and Group Functioning. ONR Technical Report #13.

PROBLEMS OF COMMANDER INTERACTION WITH STORED LOGIC MACHINES IN NAVY AAW OPERATIONS

J. W. Gebhard and R. M. Hanes
Applied Physics Laboratory

Problem

The advent of computer aids in tactical command action is imminent. This has raised a number of new problems in man-machine interaction. Some of these problems relate to commander interaction with stored-logic computers for conducting Navy AAW operations.

Review of Data

APL Studies

Experiments I and II.

We will now review the available data bearing on the problem. It will be seen that these are largely from one source--the APL series of studies of tactical command decision. In two simulation experiments designed for another purpose, a Standard Operating Procedure (SOP) for organizing and conducting an air defense operation won the universal approval of 14 Navy officers (1, 2). Nevertheless, these same officers during the air battles clearly took over control from the SOP and made most of the decisions themselves as measured by the various commands given to the weapons systems. The SOP was not a computer program, although it could have been, and the agents carrying out the SOP were people and not an electronic computer. It was thought, therefore, that the commanders might have distrusted civilians to work according to an agreed-upon SOP, but that they might have trusted a computer to carry out a stored logic program.

Experiments III and IV.

Therefore, it was decided to simulate a computer by deriving the logical outcomes of applying a set of rules to the air battle inputs. The rules of the program were given to the commanders for study, and during the games the outcomes were displayed to the commanders as recommendations. As indicated above, the commander was shown as many as five recommendations at once. Four of the recommendations were statements (in abbreviated symbology) such as: "Red CAP to Racket 3 at cruise speed"; "Green CAP to Bogey PAPA 1 at dash speed"; "Missiles to Bogey OSCAR 2"; "Return Yellow CAP to the carrier". The fifth recommendation, when made, was always the same: "Launch CAP". The commander had a keyset with five buttons, one for each recommendation. By pressing the appropriate button he could reject any of the recommendations. Failure to reject meant acceptance, and at 30 sec. following the recommendation, the command was automatically sent out on the communications net. The buttons on the keyset were lighted green for 20 sec. following the recommendation, then they turned yellow for 10 sec. as a warning that time was running out. Then they went out or were replaced by new recommendations. Pressing the button turned it red, signaling the crew simulating the computer to hold action. The commander then had to convey verbally his desired changes to the Force system. The layout of this system is shown in Figure 1.

In the first computer simulation experiment conducted in 1962 (Experiment III), a group of eight professional Navy CIC officers and evaluators with the rank of Commander or Lt. Commander served as the Sector Anti-Air Warfare Commanders (3, 4). After practice with both the manual and machine modes of operation, his task was to conduct a series of computer-aided air defense engagements in the courtermeasures environment. In this experiment a single, general-purpose program was written by analysts to handle the attacks.

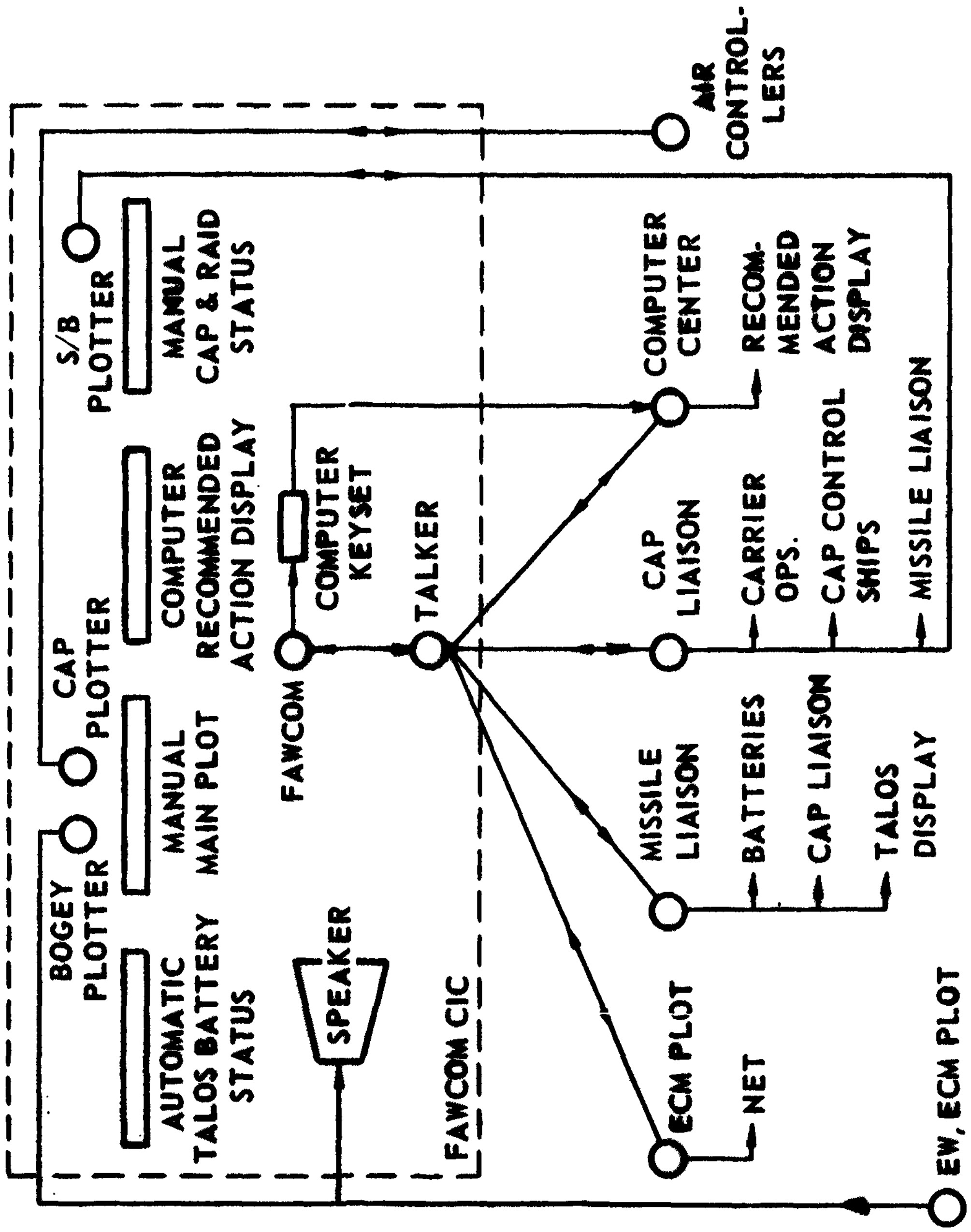


Fig. 1 COMMUNICATIONS NET IN THE FORCE AAW SIMULATION CONDUCTED IN EXPERIMENT III AT APL

The second computer simulation on a group of 12 Navy officers was completed in September 1963 (Experiment IV). In this more elaborate experi- the commander had to base his choice among three machine programs upon intelligence information. Two of the programs were designed to be specifically applicable, one to a single-prong and one to a broad-front attack. The third was a general defense much like that used in Experiment III. This work will be published in 1964 (5). The following pages contain selected results from Experiments II and III.

Comparison of Experiment II with Experiment III

Table 1 shows how the four commanders working with the SOP of Experiment II compare with the eight commanders of Experiment III who had a machine program. Under all conditions it is seen that the commanders issue a large percentage of the orders assigning weapons to targets. The slower attacks in the clean (no ECM) environment represent the least difficult situations. Yet even here the commanders give nearly half the assignments for both the SOP and program conditions. Note also that they treat both SOP and programs in nearly the same way. When the situation becomes more difficult, as in the ECM environment and with the higher-speed raids, they take over control to a much greater extent for target assignments. This tendency to assume more control in difficult situations increases with the difficulty of the situation for both SOP and program. A similar result has been reported by Sinaiko (6). The results also show that in the ECM environment the commanders rely (trust?) on the machine program more than the SOP, especially for CAP speed and other orders. The speed orders determine how fast the CAP will fly and the "other" orders consist of instructions to return to CAP stations or the carrier, etc. The data bear out the commanders' assertions that they like the machine for "housekeeping" activities, but not for making the crucial assignment decisions, especially when the going gets rough.

Table I. Commander override for different types of orders. (Each entry is mean % of orders of each type issued by the commander.)

Environment	Type of Order	Target Speed M 0.9 Expt. II[1] (SOP)	Target Speed M 0.9 Expt. III[2] (Program)	Target Speed M 1.8 Expt. II[1] (SOP)	Target Speed M 1.8 Expt. III[2] (Program)
Clean	Target	48	47	60	69
	CAP speed	56	51	56	42
	All other	62	45	61	28
ECM	Target	81	61	85	74
	CAP speed	70	42	67	44
	All other	68	44	59	21

[1]Reference 2

[2]Reference 3

Commander-Computer Interactions in Experiment III

Number of target orders issued. Table II is a comparison of the mean number of orders per battle issued by the computer when operating automatically, with those issued by the computer-commander team for various conditions of the experiment. It is to be noted first that for all conditions the man-computer combination generates more orders than the computer does alone. This is relatively more pronounced in the fast games, although the absolute number of orders given in the fast games is less than in the slow ones due to the difference in the duration of the games. With the commander in charge, the number of orders issued by him alone is, in seven cases out of 12, greater than what the computer alone would issue. The effect of this is to disburden the computer in various amounts in all cases but two, where the computer issues more orders than it would have in the automatic mode. Even so, the computer still issues a large number of orders on the average, thus making the man-computer combined averages so high. The effect of this on communications is obvious.

The computer alone issues about the same number of orders in the ECM and clean environments. In most cases, the commander issues more orders in the more complex ECM condition. This causes the machine to follow suit in some cases. In all of these comparisons, however, there is an interaction involving tactics. The differences between the ECM and clean environments are smaller for all entries in the table under the 4-prong raids than they are under the 2- and 1-prong conditions. This is due to the confusing nature of the 2- and 1-prong raids where the attackers are packed more closely together. The 2- and 1-prong raids are especially confusing in the presence of jamming, and the commander reacts to this by issuing a large number of orders in an attempt to handle the situation.

Table II. Mean target orders given by the computer alone and the man-computer team for various battle conditions. Reference 3.

Raid Speed and Countermeasures	Tactics and Automation											
	4-prong				2-prong				1-prong			
	Automatic	Semi-automatic			Automatic	Semi-automatic			Automatic	Semi-automatic		
	Cptr. alone	Cptr. under Cdr. Ctl.	Cdr. while using Cptr.	Total: Cptr. + Cdr.	Cptr. alone	Cptr. under Cdr. Ctl.	Cdr. while using Cptr.	Total: Cptr. + Cdr.	Cptr. alone	Cptr. under Cdr. Ctl.	Cdr. while using Cptr.	Total: Cptr. + Cdr.
M = 0.9												
ECM:plot	11.0	7.2	10.1	17.3	12.0	11.0	16.4	27.4	10.0	9.9	16.8	26.7
Clean	13.0	9.8	10.1	19.9	10.0	8.8	6.9	15.7	7.0	8.6	6.9	15.5
M = 1.8												
ECM:plot	5.0	3.1	12.4	15.5	7.0	6.0	12.0	18.0	5.0	5.4	17.4	22.8
Clean	8.0	3.8	11.2	15.0	7.0	3.6	7.5	11.1	4.0	2.6	3.6	6.2

Type of override on target orders. In overriding the computer the commander could 1) reject a recommendation and either issue a substitute order or do nothing; 2) anticipate a recommendation and give it before the computer would; and 3) issue substitute or different orders either following a rejected computer recommendation or at any time. The following tables contain statistically significant effects that involve rejections, anticipations, and substitutions for specified conditions of the experiment. Certain of the tables have been arranged on the same pages to facilitate comparisons that will be discussed shortly.

Tables III and IV show that commanders differ in how they interact with the automated program in giving target orders to counter the high speed attacks. Since no data are presented for the M 0.9 attacks, this means that no significant commander differences were found. Table III shows that rejections, anticipations, and substitutions differed significantly for the first four commanders and the 60 sec. assessment time with respect to countermeasures. Table IV indicates that the last four commanders who worked with the 30 sec. assessment time simply differed with respect to each other--by a factor of nearly 3 to 1 in the number of orders issued.

The next four tables are arranged on the same page to show how override, as measured by target orders, interacts with countermeasures. Tables V, VII, and VIII show an interaction with countermeasures; Table VI does not. For the conditions shown in Tables V and VIII, substantially less override occurs in the clean environment . Table VII, however, shows that this is not always the case as indicated by the interaction with tactics. Under all conditions shown, the commanders anticipate the computer recommendations much more than they reject them, and issue in addition a large number of substitute target orders of various kinds that are not provided for by the machine program.

Table III. Individual differences in type of commander override on target orders showing interaction with countermeasures. (Each entry is mean number per game.)

M 1.8 attacks, 60 sec. assessment time, commanders 1-4	Type of override	Commanders and Countermeasures								
		1		2		3		4		Mean
		Clean	ECM	Clean	ECM	Clean	ECM	Clean	ECM	
	Rejections	0.7	0	0	0	1.3	0.7	0.3	1.0	0.5
	Anticipations	5.3	2.0	4.3	4.0	1.7	0.7	1.0	1.3	2.5
	Substitutions	3.0	3.3	9.3	5.7	4.0	8.3	2.3	6.3	5.3
	Mean	7.2		11.6		8.4		6.1		

Table IV. Individual differences in type of commander override on target orders. (Each entry is mean number per game.)

M 1.8 attacks, 30 sec. assessment time, commanders 5-8	Commanders			
	5	6	7	8
	5.0	7.2	14.0	7.0

Table V. Type of commander override on target orders as affected by countermeasures. (Each entry is mean number per game.)

	Counter-measures	Type of Override		
		Rejections	Anticipations	Substitutions
M 0.9 attacks, 60 sec. assessment time, commanders 1-4	Clean	0.8	2.8	3.2
	ECM	1.2	4.2	7.9
		1.0	3.5	5.6

Table VI. Type of commander override on target orders for a condition of the experiment showing no interaction. (Each entry is mean number per game.)

	Type of Override		
	Rejection	Anticipation	Substitutions
M 0.9 attacks, 30 sec. assessment time, commanders 5-8	0.5	1.8	5.6

Table VII. Type of commander override on target orders as affected by countermeasures and tactics. (Each entry is mean number per game.)

	Counter-measures	Tactics and Type of Override								
		4-prong			2-prong			1-prong		
		Rej.	Ant.	Sub.	Rej.	Ant.	Sub.	Rej.	Ant.	Sub.
M 1.8 attacks, 60 sec. assessment time, commanders 1-4	Clean	0.8	2.0	7.2	0.8	3.0	3.2	0.2	1.8	1.2
	ECM	0.5	3.2	6.8	0.2	2.8	4.5	0.5	2.5	9.0
		0.6	2.6	7.0	0.5	2.9	3.8	0.4	2.2	5.1

Table VIII. Type of commander override on target orders as affected by countermeasures and tactics. (Each entry is mean number per game.)

	Counter-measures	Rejections	Anticipations	Substitutions
M 1.8 attacks, 30 sec. assessment time, commanders 5-8	lean	0.3	1.2	4.2
	ECM	0.6	1.9	8.2
		0.4	1.6	6.2

Interaction patterns in override on target orders. The grouping of Tables III and IV and V - VIII permits one to see an interesting relationship between the conditions of the experiment and the nature of the override. It is reasonable to suppose that the 60 sec. computer assessment time gives the commander a better opportunity to evaluate the situation and to become dissatisfied with the operations of the system. It is also reasonable to believe that the high speed attacks, where much occurs quickly, impress the commander with the sluggish nature of a system in which new information is "digested" by the computer for a full minute before action is recommended. A comparison of Tables III and IV shows that the complex interactive relation with countermeasures appears where the assessment time is long rather than short, although the target speed is the same. This same effect for the M 0.9 targets is shown in comparing Tables V and VI and again for the M 1.8 targets in comparing Tables VII and VIII. Holding assessment time constant at 60 sec., more complex interactions are shown in Table VII when compared with Table V. The same is true for the 30 sec. time as shown by the interaction seen in Table VIII but not in Table VI where the speed is slow. Table VII, where the assessment time is long and the target speed is such as to call for vigorous action, contains the most complex interaction of all.

It appears, therefore, that when enemy action develops rapidly (M 1.8 raids) with respect to computer assessment time (60 sec.), the pattern of override is affected by more factors.

Summary

Professional Navy evaluators were willing, in a simulated AAW situation, to cooperate in various degrees with an experimental system of automated decision-making. While some officers effectively negated the use of the computer by issuing large numbers of anticipatory and substitute orders, no one turned the computer off. The concensus was that the computer was most valuable as a back-up to the commander, and that it was most acceptable for its housekeeping functions. It was less satisfactory for making critical weapons-to-target assignments, establishing the pace of the battle, and determining the defensive posture of the Force weapons systems. In particular, commanders objected to elements in the logical program that led to early depletion of their CAP reserves, and tactics that reduced their ability to handle a second strike, or tended to leave their flanks exposed. While unanimity was not expressed, the system that automatically put non-rejected recommendations into effect as orders was generally liked, and it was felt that the machine should "force" the commander by placing a limit on his time for evaluating recommendations. It was agreed that working with a machine aid, as simulated in the laboratory, was a rewarding experience, and that automation in decision-making will be acceptable to most commanders in Force AAW operations providing adequate provision is made for controlling the computer.

References

1. Hanes, R. M., Gebhard, J. W., and EMCH, G. F. Studies of tactical command decision. I. Effects of attack tactics on a high performance defense in an ECM environment. APL/JHU Rep. No. TG-450-1, 30 October 1962. SECRET

2. Hanes, R. M., Gebhard, J. W., and EMCH, G. F. Studies of tactical command decision. II. Effect of quality of target position information on a high performance defense. APL/JHU Rep. No. TG-450-2, 1 February 1963. CONFIDENTIAL

3. Hanes, R. M. and Gebhard, J. W. Studies of tactical command decision. III. Commander acceptance and use of automated command-control procedures. APL/JHU Rep. No. TG-450-3, 1 November 1963. CONFIDENTIAL

4. Hanes, R. M. and Gebhard, J. W. Acceptance of standard operating procedures in tactical decision. APL/JHU Rep. No. TG-455, 30 November 1962. CONFIDENTIAL

5. Hanes, R. M. and Gebhard, J. W. Studies of tactical command decision. IV. Commander acceptance and use of specific machine logics to counter specific threats. APL/JHU Rep. No. TG-450-4. In preparation.

6. Sinaiko, H. W. Artful: An experimental study of an automatic air defense system under varying conditions of human intervention. University of Illinois, Control Systems Laboratory, Rep. No. R-104, June-July 1958.

TRAINING IN DECISION-MAKING

R. G. Kinkade
AIRCRAFT ARMAMENTS, INC.

One of the primary missions of an AAW command is to defend against an air attack. However, a collateral mission is to deter such an attack. Success in accomplishing the collateral mission results in a condition whereby an effective AAW system is seldom employed in a combat situation.

The Commander or Staff Officer who is responsible for evaluating the threat from a potential enemy may find that he is more concerned with information about housekeeping functions than he is about the enemy when the system is in the standby mode. Under these circumstances, tactical information probably is not directly impactive on the evaluator.

If an attack does occur, the evaluator must be able to change the focus of his attention and immediately assess the threat to the area that he is defending. To do this, he must be able to quickly evaluate his information about the enemy and about his own combat resources and decide on a course of action.

Effective decision-making under these circumstances will depend upon the evaluator's clear understanding of the relationship between the available information and the probability of success of each course of action open to him. Generally, the evaluator should select that tactic that has the highest probability of producing success.

Research has shown that people are severely limited in their information processing ability. Decision effectiveness dramatically decreases when a decision-maker has to consider information about a number of parameters before he can rationally select a tactic. However, decision performance can be made more effective through appropriate training.

Preliminary studies at AAI have shown that practice in a situation where feedback is in the form of the decision-maker's error in estimating the probability of success increases decision effectiveness. After practicing in such a situation a decision-maker can learn to maximize his probability of success. On the other hand, practicing in a situation where feedback concerning the appropriateness of a decision is in the form of the outcome of the decision, success or failure, does not increase effectiveness. In fact, decision effectiveness appears to decrease and the decision-maker adopts behavior patterns which are analogous to superstitious behavior.

Since the inputs to the decision-maker can be controlled in a training situation, the benefits of using error in estimating the probability of success for alternative tactics could be easily obtained. Once the evaluator has been trained in such a situation, he will understand the relationships between his tactical information and the probability of success of his decision alternatives. This should permit him to evaluate his tactical information faster and more effectively than he would be able to when he is trained in a situation where the ultimate outcome of his decision is given as feedback.

The Human Factors Group at AAI is continuing to investigate variables associated with training decision-makers. One study concerns the determination of procedures for training people to formulate the alternative tactics that are available to them. There is some anecdotal evidence that suggests that people make decisions without first considering what alternatives are available to them.

Another area of interest is to test the Progression Hypothesis in a decision-making situation. The basic notion here is that if a trainee could start his training at a relatively simple level and progress to more complex levels as a function of his decision effectiveness, acquisition of decision-making skills would be facilitated more than if he were to start at a complex level. These research projects are in their early stages and data collection has not yet begun. However, initial computer programs have been written and pilot studies will be inaugurated soon.

Summary of

TEAM TRAINING AS A FUNCTION OF TASK ORGANIZATION, TASK COMPLEXITY, AND SKILL LEVEL OF SUBSTITUTE TEAM MEMBERS[1]

by

James C. Naylor and George E. Briggs
Ohio State University

An "operational" task was defined by a special-purpose analog computer which required a three-man team to observe aircraft returns on a simulated radar display and to communicate commands to eight interceptor aircraft as targets appeared on the displays. The team continued to emit commands until they felt a successful intercept was achieved; a constant load of eight targets was maintained, each on a different but constant speed and heading course. The pilots were members of the experimental staff who implemented commands on target generators and maintained records of these commands.

Each team received three days of training on an abstract version of the operational task followed by four days on the operational task itself. On the third day of operational task duty, a replacement was made of one of the team members and the replacement was either more experienced or less experienced than the man he replaced. Two other variables were manipulated systematically: (1) task organization occurred at two levels, one in which team members worked independently of one another and the other in which interaction between team members was encouraged; and (2) task complexity occurred at two levels, one in which the team had the relatively difficult job of commanding heading, speed, and altitude changes for the interceptors and the other in which the team only had to issue speed and heading commands. Four teams were run under each of the eight combinations of the three independent variables.

The results in terms of system efficiency are summarized in Fig. 1 for the "operational" task performance. The terms 2D and 3D refer to the task difficulty variable. Figure 2 shows the results for another dependent variable: percent successful interceptions which were defined as vectoring an interceptor aircraft to within two nautical miles of its target. By statistical analyses of the data of Fig. 1, the following conclusions were drawn:

1. There were no significant interactions of the three independent variables; thus, their influence on team performance (see below) was quite straightforward.

2. Task complexity was a very potent determinant of system efficiency both before, during, and after replacement of a team member. System efficiency was higher for the less complex task.

3. The amount of training of the replacement operator was important only at the time of replacement. By the next work session this was not a significant variable; thus, there appears to be only a short-term effect of this variable as, apparently, the team adapts to the new operator's skill level rather quickly. As expected during initial replacement the more experienced replacements improved system efficiency markedly while no improvement occurred in teams which received a less skilled man as replacement.

4. System organization did not influence system efficiency until after the replacement of a team member occurred; then it affected efficiency for two work sessions (until the end of the experiment). Thus, system organization appears to be a benign variable that does not become important until the system is stressed (as with a replacement), but once "triggered" it has a relatively lasting effect on team performance (unlike replacement skill level which had only a short-term effect). This effect was one of greater efficiency for teams operating under the independent than under the interaction system organization condition.

Footnote

[1] This is one of three experiments conducted under Contract N61339-1327 between the U. S. Naval Training Device Center and the OSU Research Foundation. The work was carried out in the OSU Laboratory of Aviation Psychology, Dr. G. E. Briggs, Director. Dr. C. K. Bishop served as project monitor for the Navy.

Figure 1

System Efficiency on the "Operational" Task.
Experiment I, Contract N61339-1327

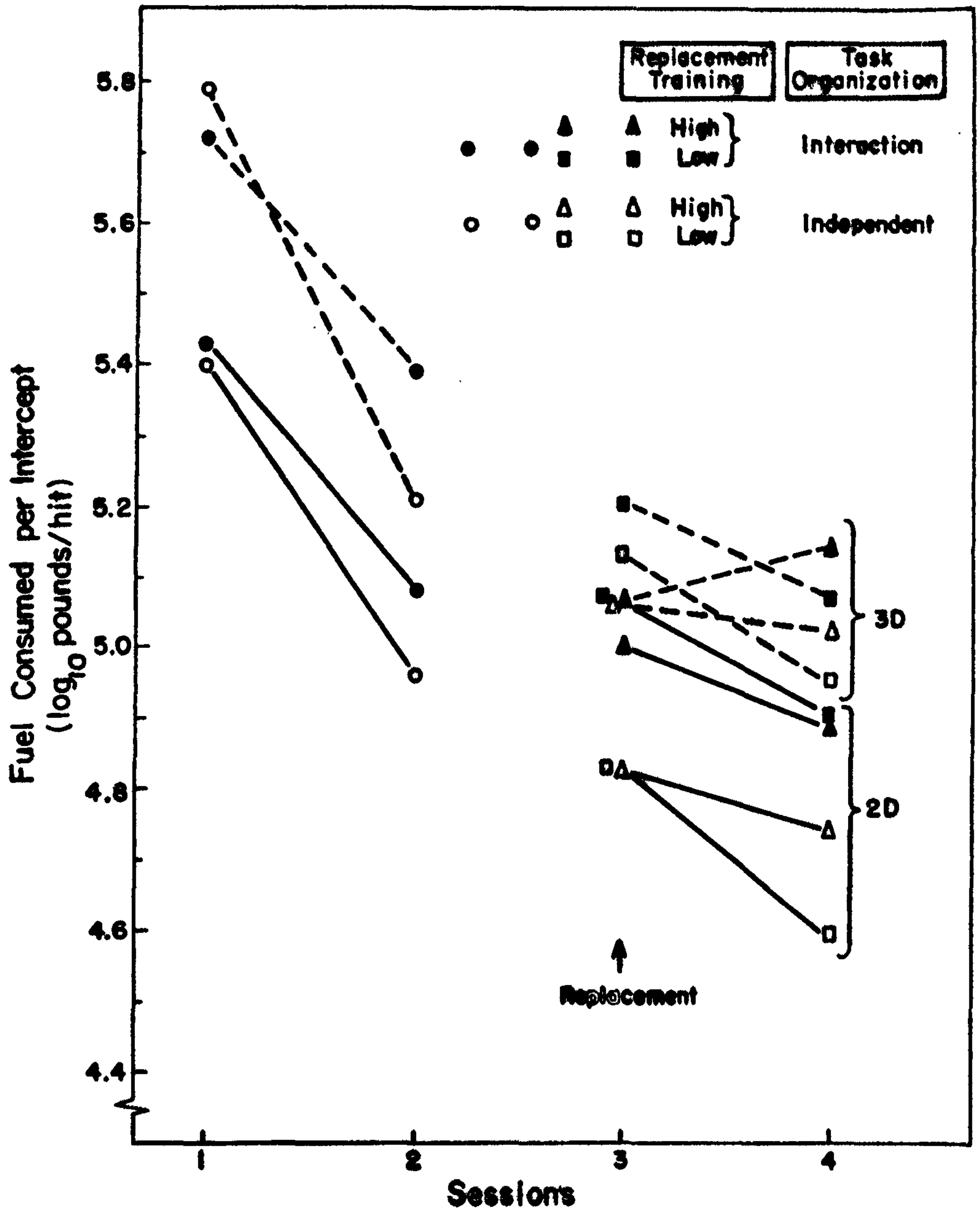
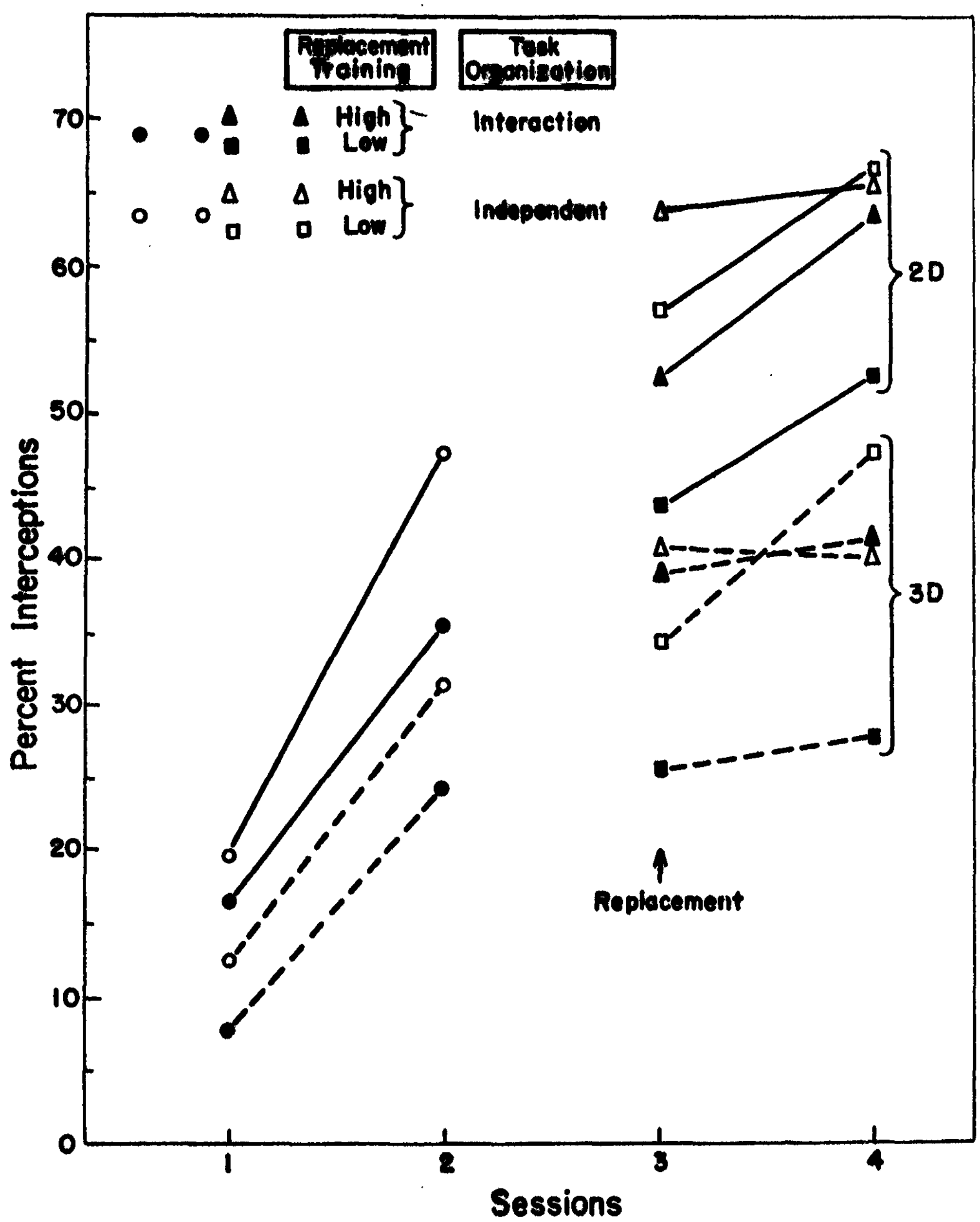


Figure 2

System Accuracy on the "Operational" Task.
Experiment I, Contract N61339-1327



INCREASING TEAM PROFICIENCY THROUGH TRAINING
A REVIEW OF THE APPROACH AND FINDINGS

I. Approach and Methodology

Robert Glaser
University of Pittsburgh

Introduction

I should like to describe an approach to the experimental study of the conditions of training that influence the acquisition and decay of group performance.

The general characteristics of the type of analysis to be considered can be illustrated by an example. Consider a two-man team in which a "monitor" obtains information and transmits it to an "operator" who processes the information and transmits the team output. This output results in a binary contingency, i.e., right or wrong, a hit or a miss. The team is connected in series since both component members must execute a correct response in order for the team to produce a response which can be reinforced. If the performance of each member is followed only by reinforcement for the team product, then several predictions can be made as to the likelihood of the occurrence of correct responses under various conditions. When both men are correct the team response will be reinforced and there will be an increase in the probability of correct individual responses. When both men are incorrect no reinforcement is forthcoming to either member and their response probabilities are decreased. When one member responds appropriately and the other not, the subsequent lack of reinforcement results in an extinction trial for the member responding correctly. In such a team situation reinforcing events which are contingent upon the team response follow the preceding response of all team members "indiscriminately," i.e., every team member is exposed to the same event. For example, in the above series-linked-team, when one member responds incorrectly it is possible for no positive feedback to occur to the other members even though they have made correct responses. This "confounding" characteristic of team reinforcement suggests one way of defining a team -- a group of individuals who are all reinforced by a single event, the occurrence of which depends on the integrated responding of at least some of the participating members on any one trial. A central concept is that group feedback is contingent upon a composite of individual performance.

The initial major purpose of the studies we shall briefly describe is to assess the feasibility of considering the team as a learning unit which reacts to the presence or absence of reinforcement following a response in a way similar to the response of individuals as observed in a learning laboratory. Accordingly, when taken as a response unit, the team product should exhibit increments or decrements as a function of the properties of the stimulus contingencies following each trial. For example, the team should acquire proficiency in responding when feedback to the team is reinforcing, and once acquired, extinction of the team response should occur if reinforcing feedback is withheld. Study One was designed to test this hypothesis and to determine the influence of the presence and absence of group reinforcement on the performance of a series team as a unit. Study Two considered the more complicated case of a team linked in "parallel." In a parallel team a correct response by either one or more members can produce a correct team response; here the reinforcing contingencies are complicated by the fact that a team reinforcement can follow a member's performance when he makes an incorrect response.

Methodological Perspective

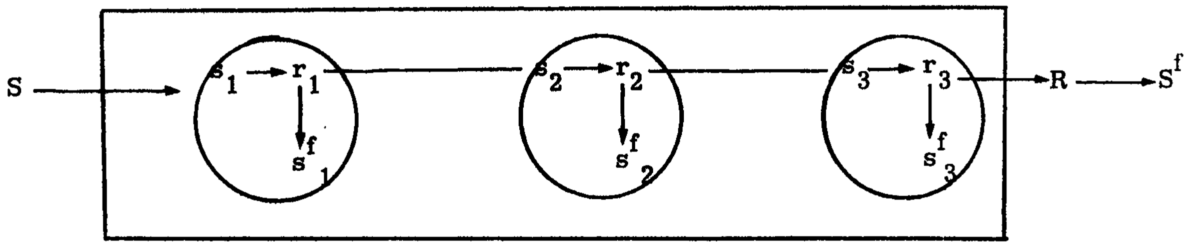
In studying the performance of a team, one level of analysis is to observe the team as a responding entity. From this point of view, one looks at the stimuli that impinge upon the group and observes the properties of the group responses that occur. It is as if the group is considered as an "empty organism" or a black box and input-output relationships are being observed for study without going into the black box. The study of team performance on the level of group input and group response can be called "molar" in the sense that the response class under consideration is a group product and not the responses of the individual group members. When a single organism is the object of study, depending upon the intent of the investigator, observations also may be made of molar events, e.g., reaction time as a function of number of stimulus choices, or concomitant "molecular" events, e.g., concurrent muscular action potentials. In an analogous manner, from a molar point of view, group response can be studied as a function of environmental contingencies without going "beneath the skin" of the group to the observation of the individual members. It is also possible, from a molecular point of view, to look at the responses of individual members as they are influenced by the team environment.

Possible relationships that can be studied on each level of investigation and across levels are illustrated in Figure 1. The diagram shows two three-man teams. In Team A, information is passed along a single line, as indicated by the directional arrows, in the same way as a simple series circuit. Team B is also connected in series -- each man must perform correctly to complete the team task -- but in this case, two team members' responses serve as the stimulus inputs to a third member. In Figure 1, the capital letters refer to group stimuli and group responses. The small letters refer to stimuli and responses with respect to the individual group members. In Team A, S refers to the stimulus event which initiates group activity. S can be considered as an external stimulus, i.e., coming from outside the group's immediate environment. R is the group response which is a function of whatever transformations have occurred by the group members "beneath the skin" of the team. S^f is the environmental consequence that is brought about as a result of the team response. S^f acts as group feedback when it is an observable event following the group response. The circles in Figure 1 refer to individual team members and s_1 refers to the stimulus input for team member 1, r_1 is his response, and s^f_1 the feedback to him or consequence of his response.

S^f and s^f may be different events depending upon the man-machine team arrangement, the remoteness of the individual team member from the occurrence of S^f, and also his opportunity to observe it. The notations in Team B have the same meaning as has been described, except that S_a and S_b refer to the fact that two environmental inputs are fed into this team. (S_a and s_1 and S_b and s_2 may or may not be similar events depending upon the nature of the team task and the construction of the communication arrangement.)

Legitimate variables for study are any of the stimuli and response relationships in Figure 1, for example: the relationship between group input S, group response R, and group feedback S^f; team member response, r_1, r_2, ...r_n, as a function of group feedback S^f; the relationship between feedback to the individual s^f and group response R; the relationship between individual feedback s^f and individual response r_1, r_2, ...r_n. As has been indicated the relationship between the team member response and group feedback is especially interesting in situations where the feedback to individuals is not the consequence of their own response, but rather the consequence of their response as confounded with the responses of other group members. Intensive investigation of these varieties of relationships should contribute to the detailed experimental analysis of team training and team performance. The studies I should like to mention illustrate primarily molar investigations of team performance and team learning. Of particular interest is the relationship between group responses R and group feedback S^f, when S^f is considered as a reinforcing stimulus. In these studies the data of primary concern are observable team output and team feedback events that occur outside the boxes in Figure 1, and the determination of orderly functional relationships between these events. The investigation stays on a molar level but looks into the "team box" for explanatory variables based upon individual performance. The general question being asked is: To what extent are molar relationships of team learning similar to the functional relationships in learning that have been identified in studies of individual or single organism learning; and to what extent does such an approach provide a basis for the further analysis of team behavior and the problems of increasing team proficiency through training?

Team A



Team B

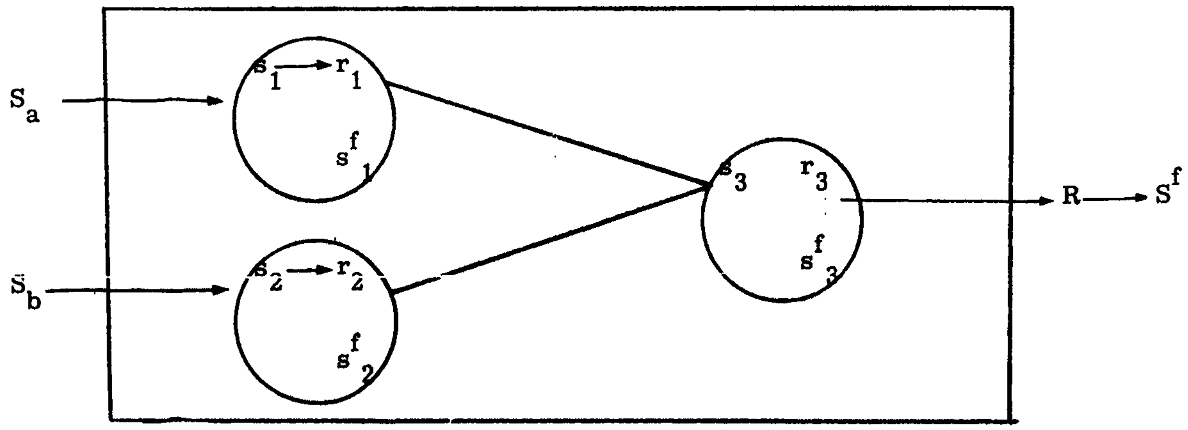


Figure 1

Molar and Molecular Team Variables for Two Series-Team Arrangements

Figures 2 and 3 show the general layout of the laboratory and subject's panel. Table 1 briefly describes the training phases and criteria for Study One. Figure 4 illustrates the three-man series team used in Study One. Figures 5 through 11 show representative findings from Study One.

Figures 12, 13 and 14 illustrate the team arrangements used in Study Two. Table 2 lists the training phases and sequence followed in Study Two. Figures 15 through 20 show representative findings obtained in Study Two.

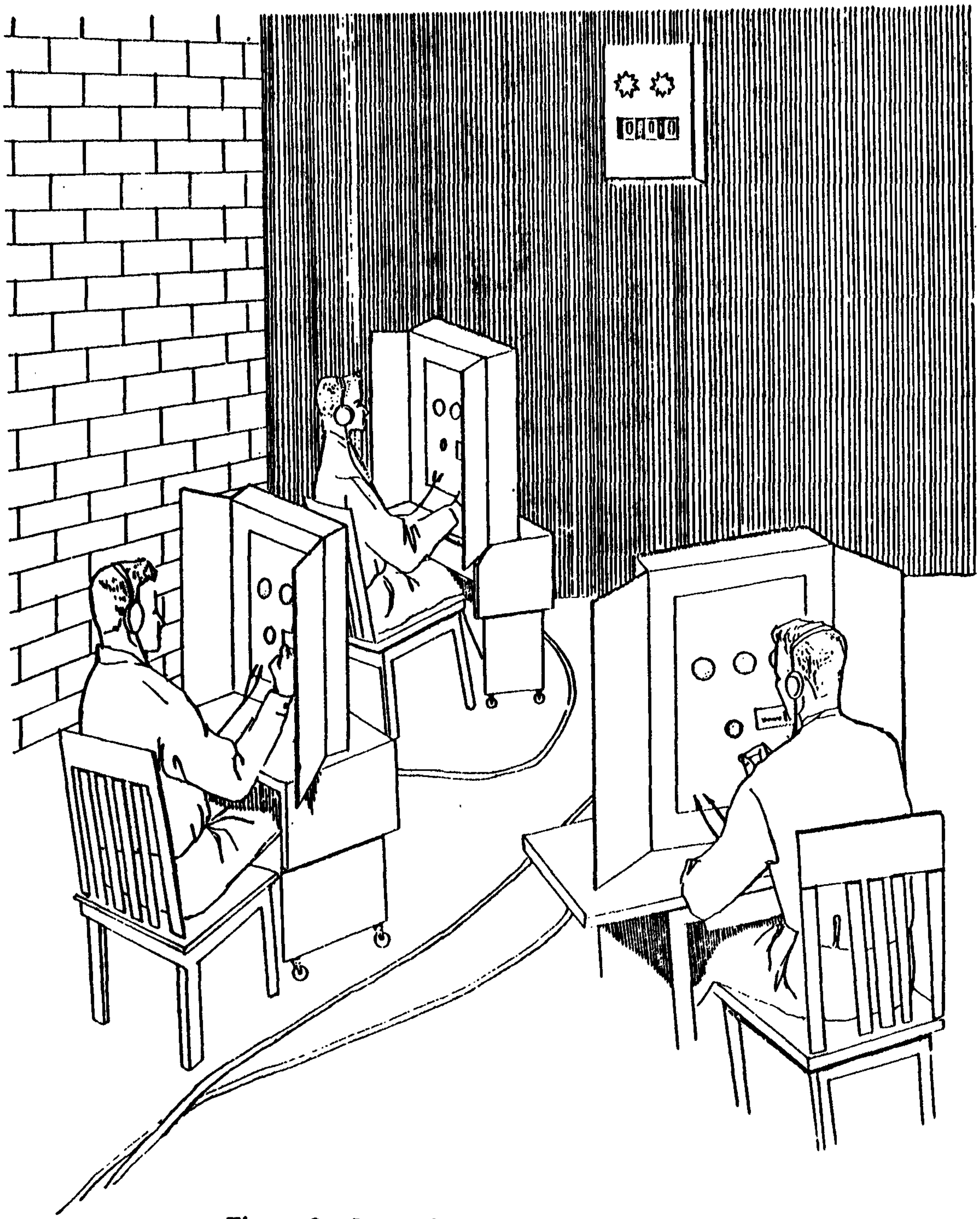


Figure 2: General Layout of the Laboratory

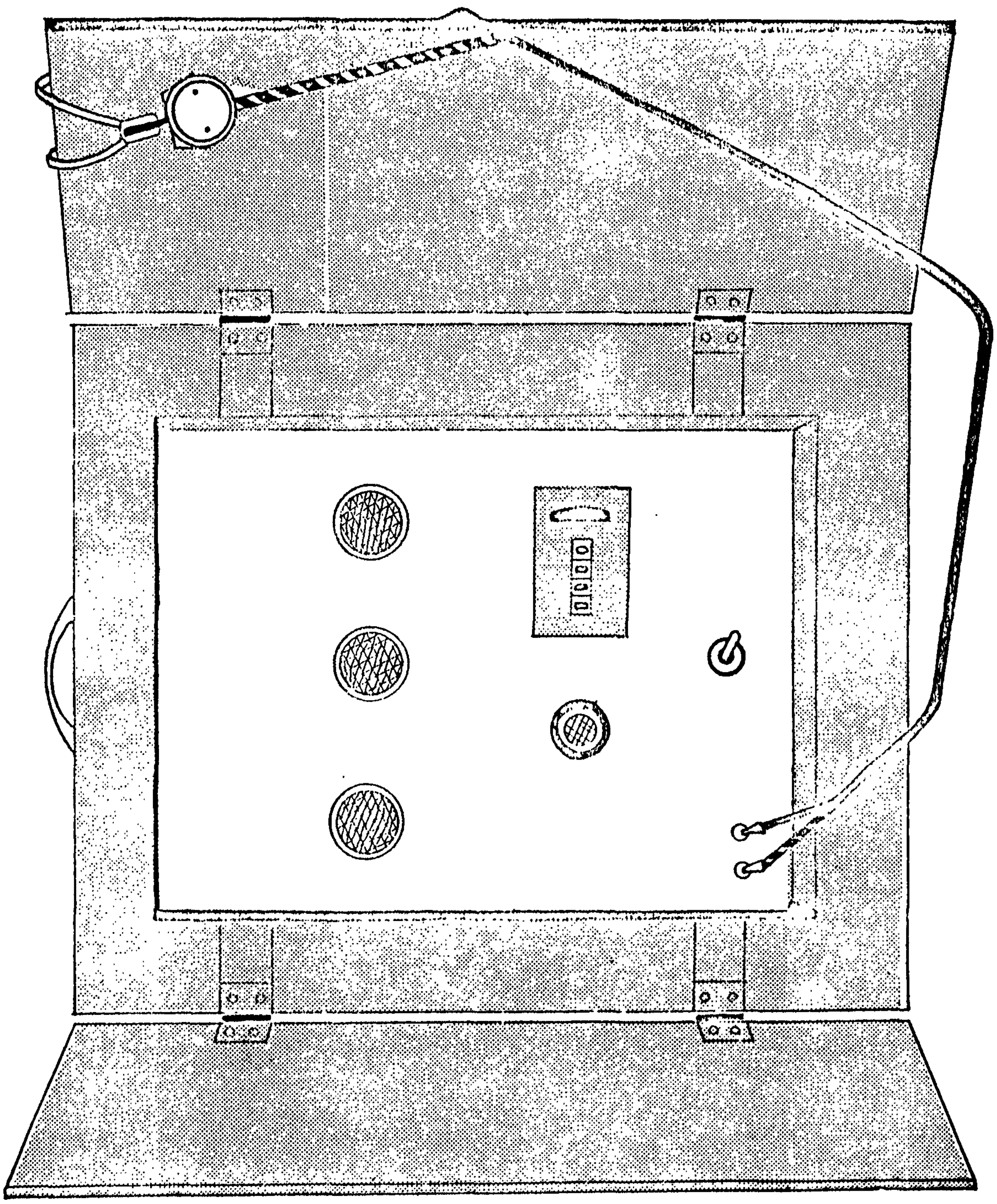


Figure 3: A Subject's Panel

Table 1

Description and Criteria of the Training Phases

Training Phase	Description	Criterion
Individual	Subjects practiced making two- and four-second time estimations.	Four consecutive five-minute periods of 63 per cent or better.
Pattern	Monitors practiced timing responses to different light patterns.	None
Three-man team	A) Ten-minutes of warm-up of the two- and four-second presses daily.	None
	B) All three subjects' performance combined in a joint effort to secure the team product.	1) Acquisition: four consecutive five-minute periods of ten or more group points. 2) Extinction: four consecutive five-minute periods of zero group points. 3) Spontaneous Recovery: two consecutive five-minute periods of zero group points. 4) Re-acquisition: (same as acquisition). 5) Re-extinction: (same as extinction).

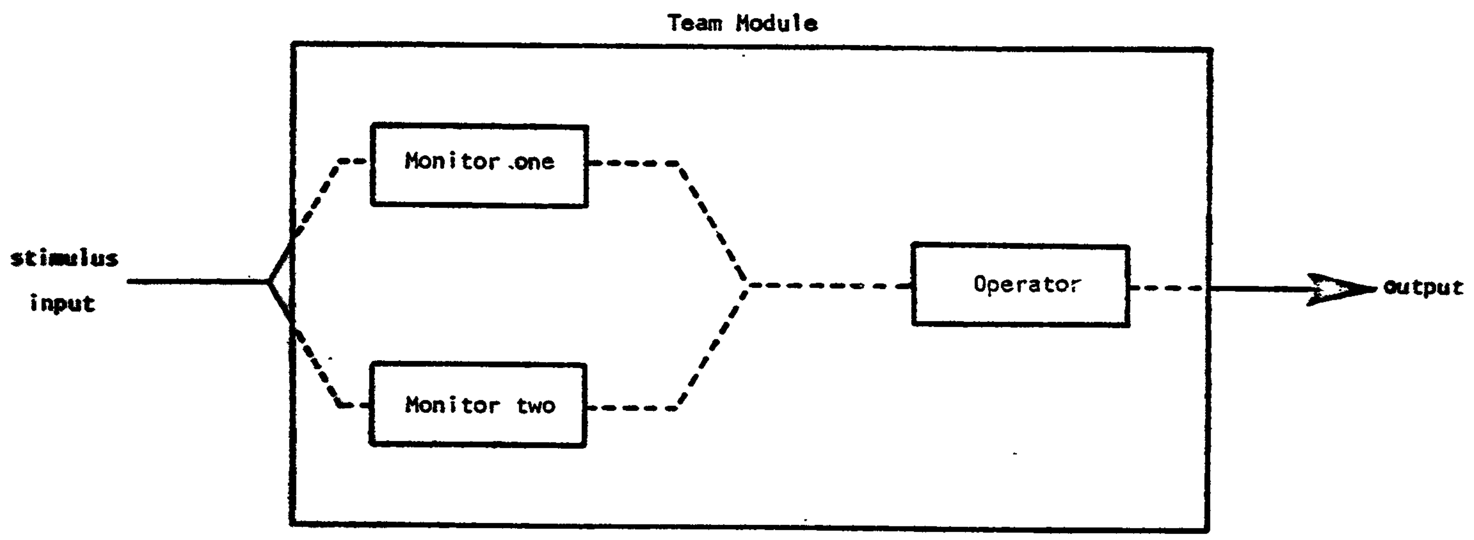


Figure 4: Schematic of a three-man series team

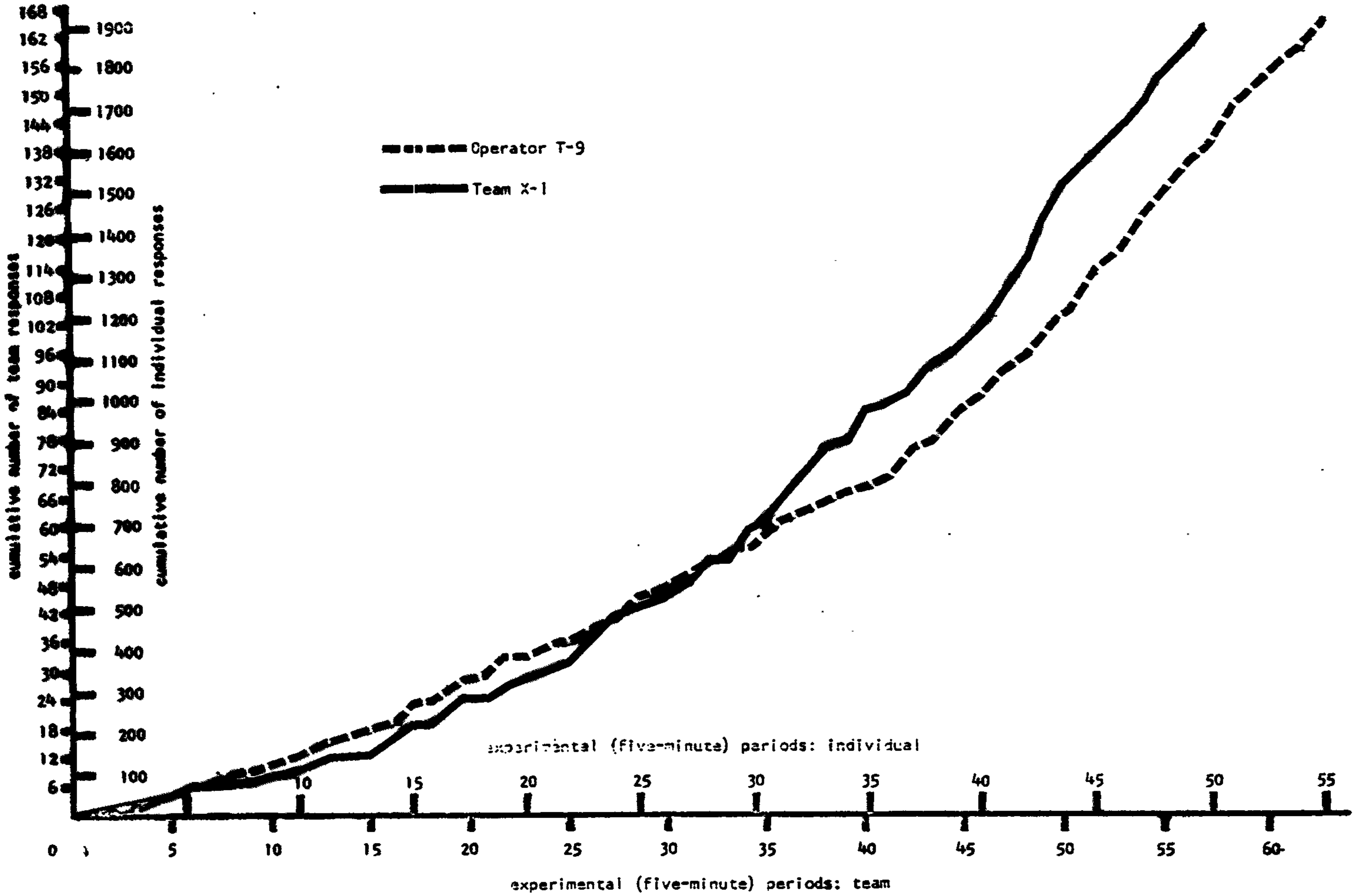


Figure 5: Comparison of acquisition curves: Individual and Team Training

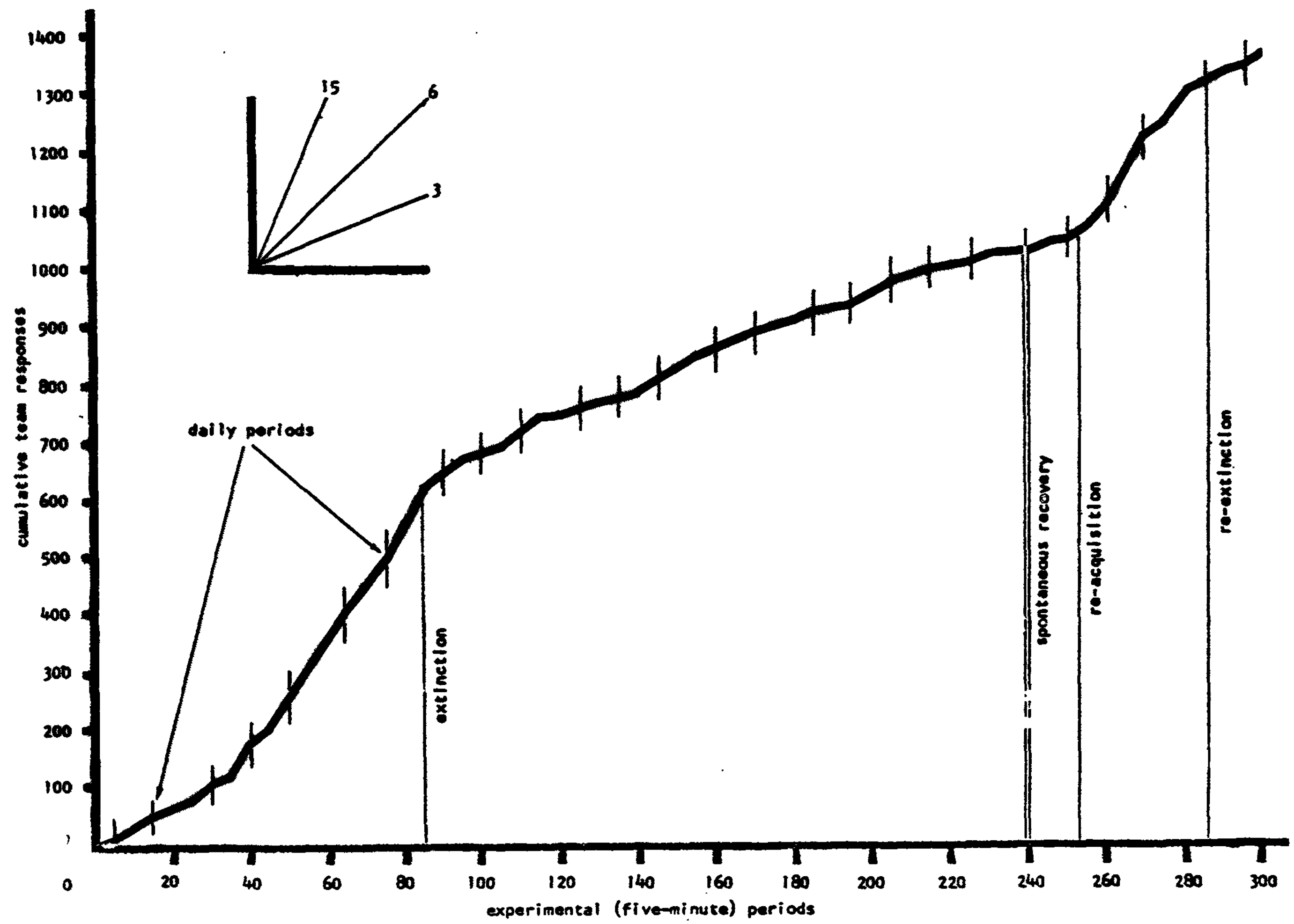


Figure 6: Three-man team training: Team T-1

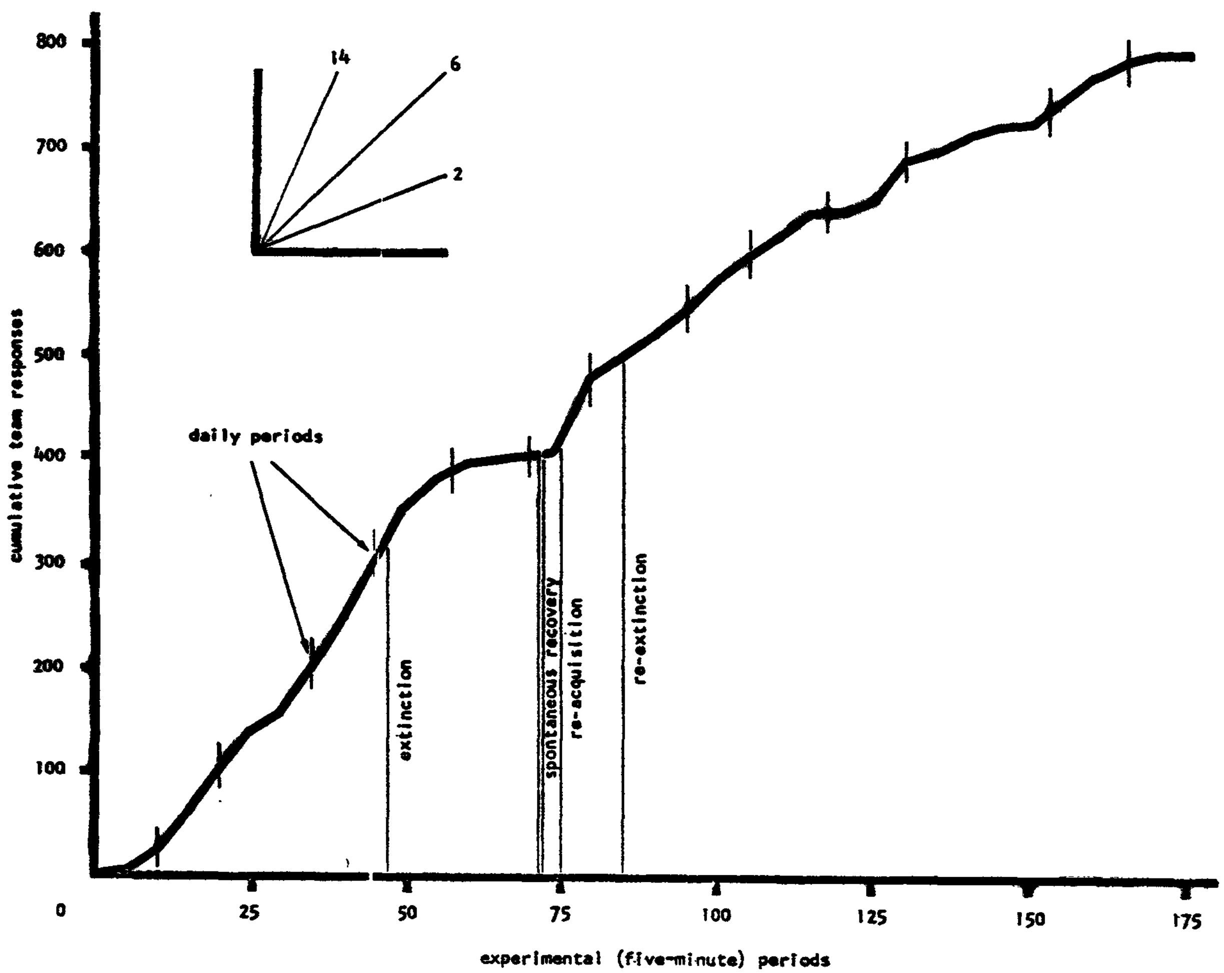


Figure 7: Three-man team training: Team T-2

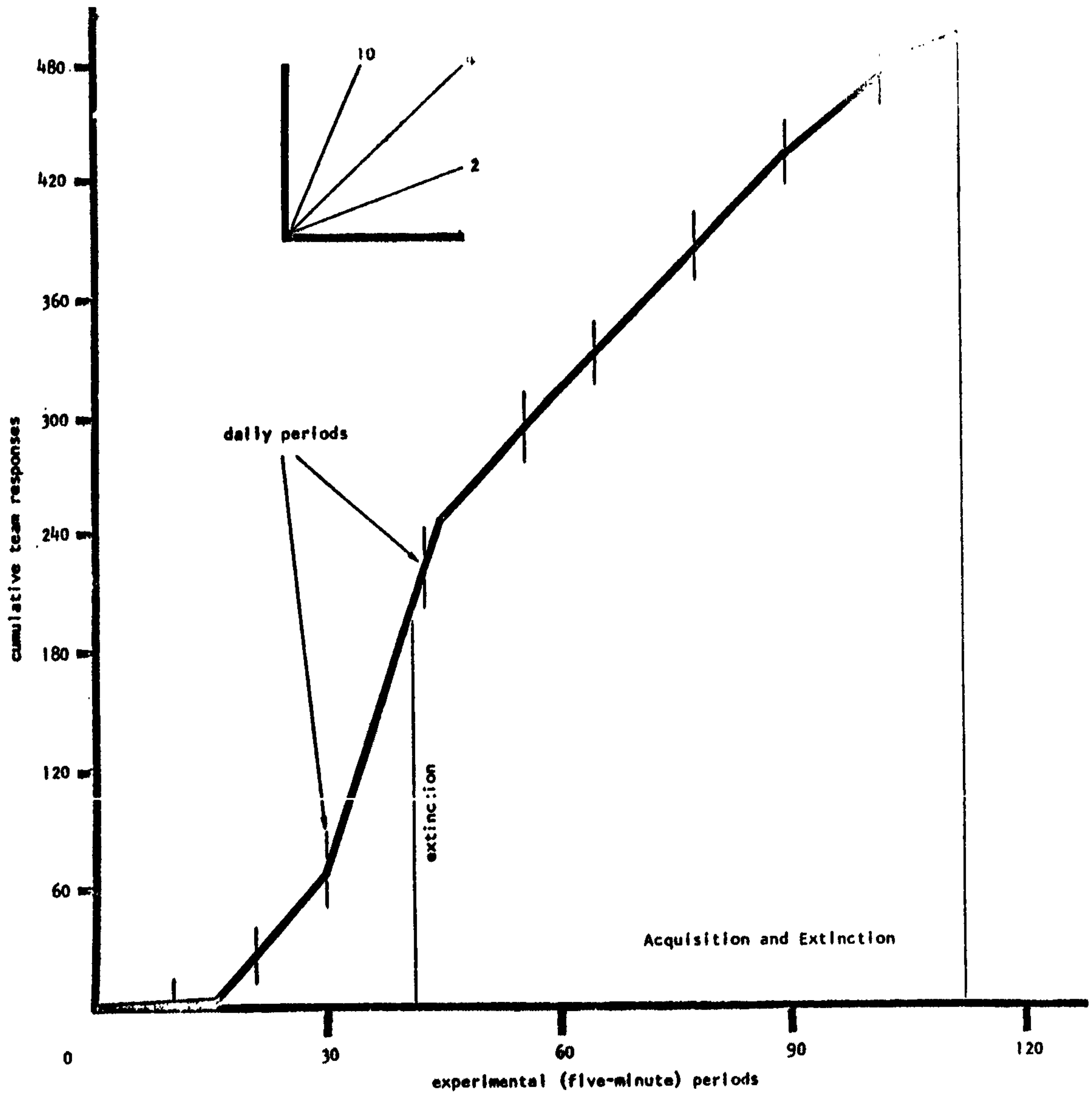


Figure: 8 Three-man team training: Team T-3

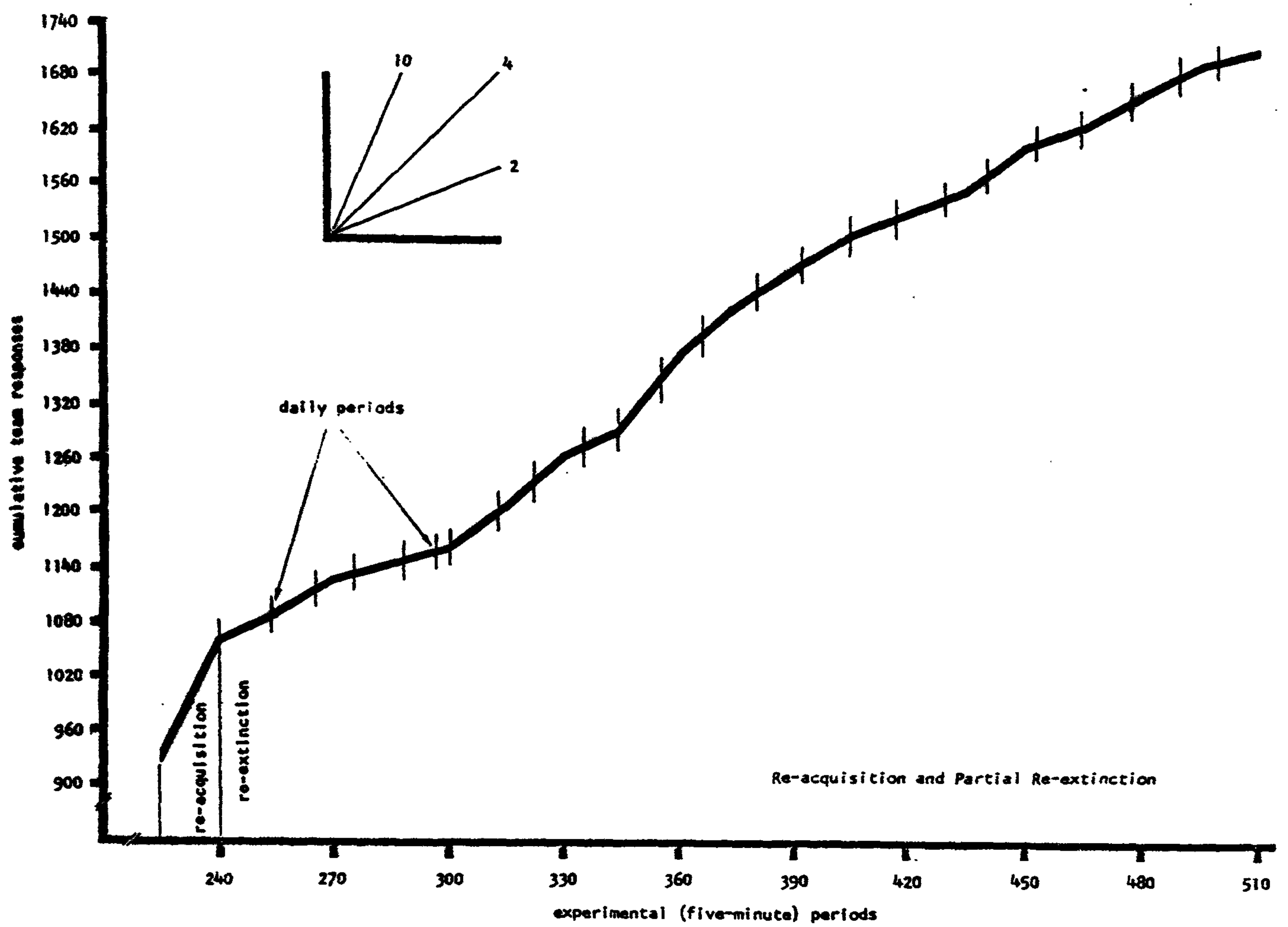


Figure: 8 (continued). Three-man team training: Team T-3

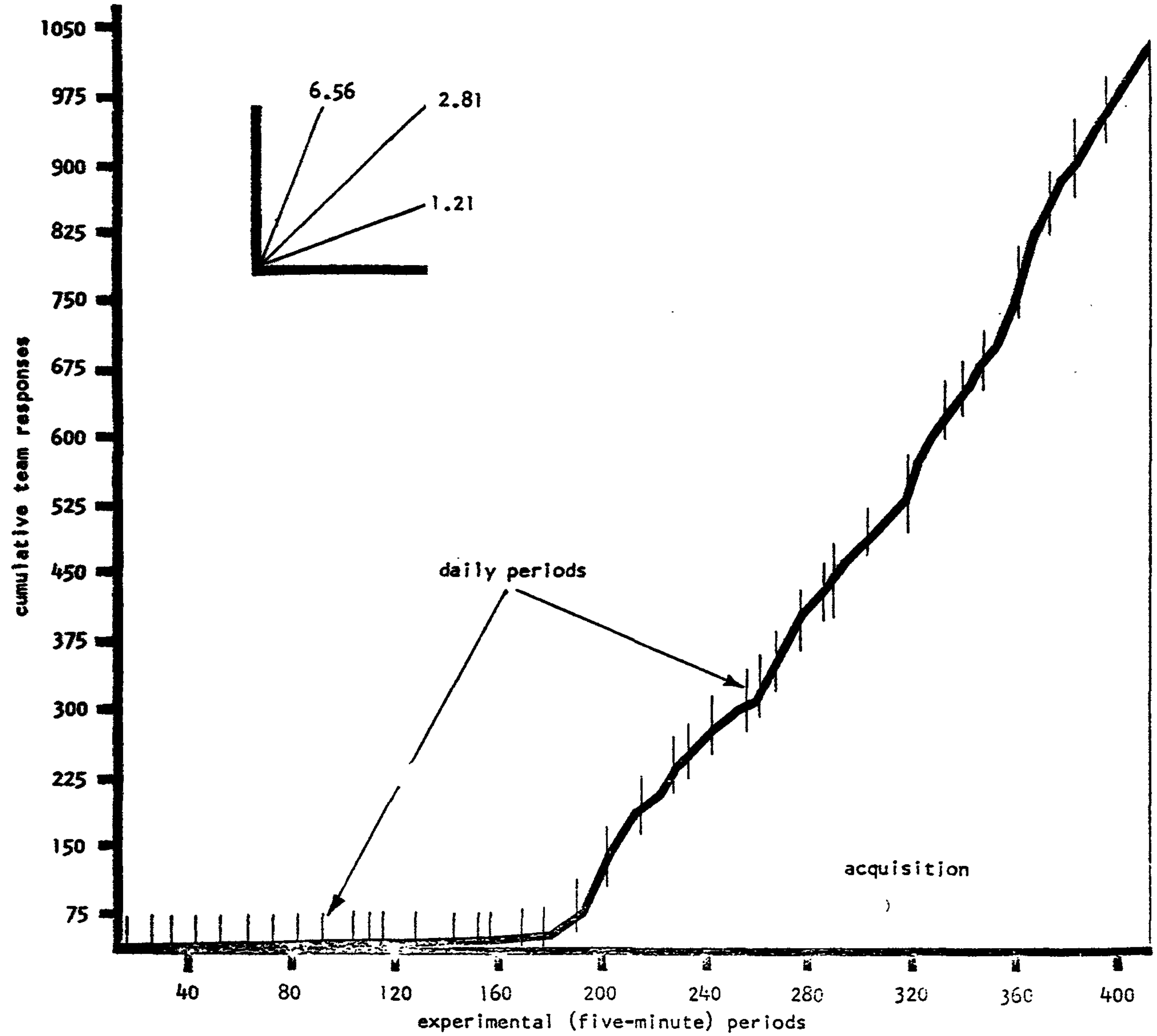


Figure: 9 Three-man team training: Team T-4

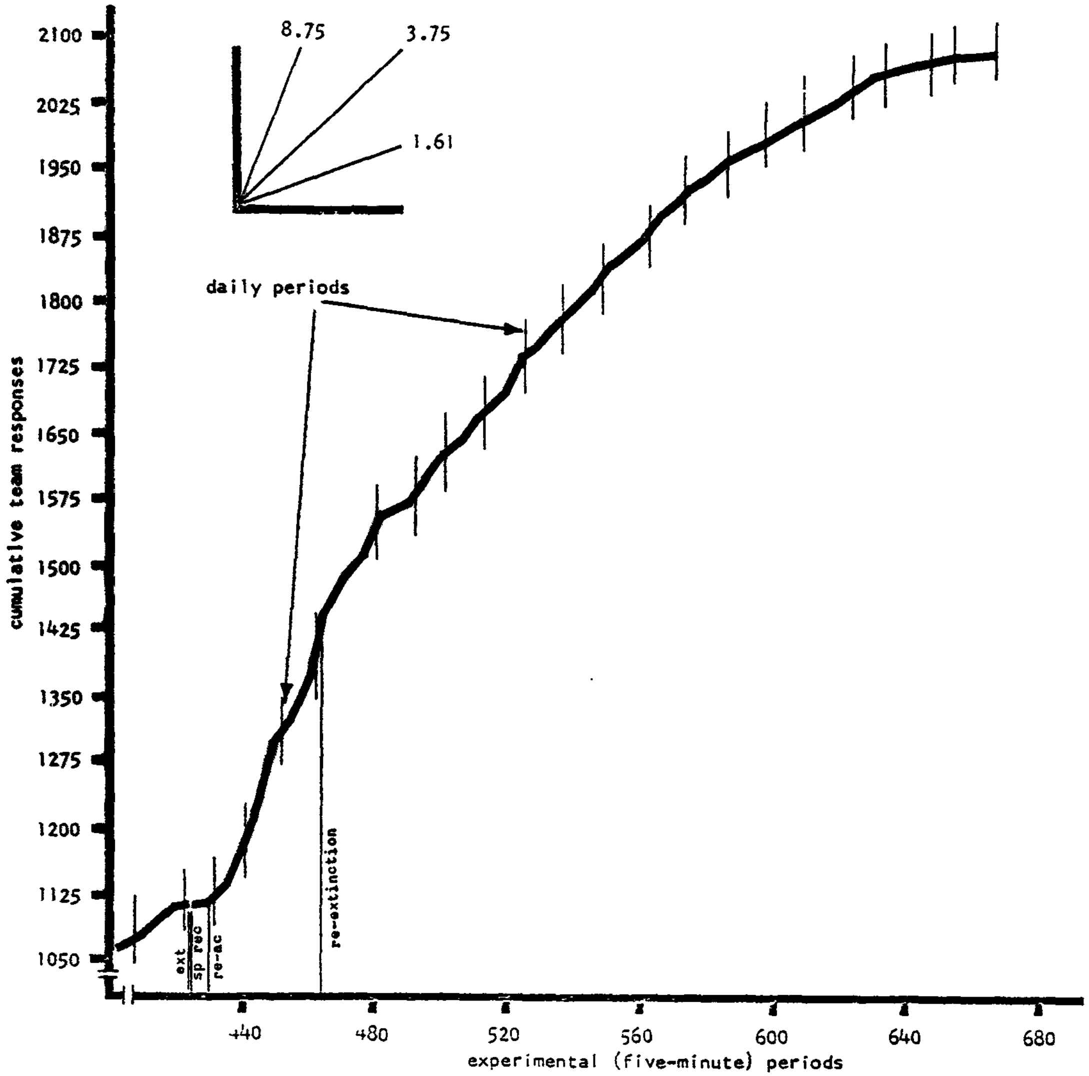


Figure: 9 (continued). Three-man team training: Team T-4

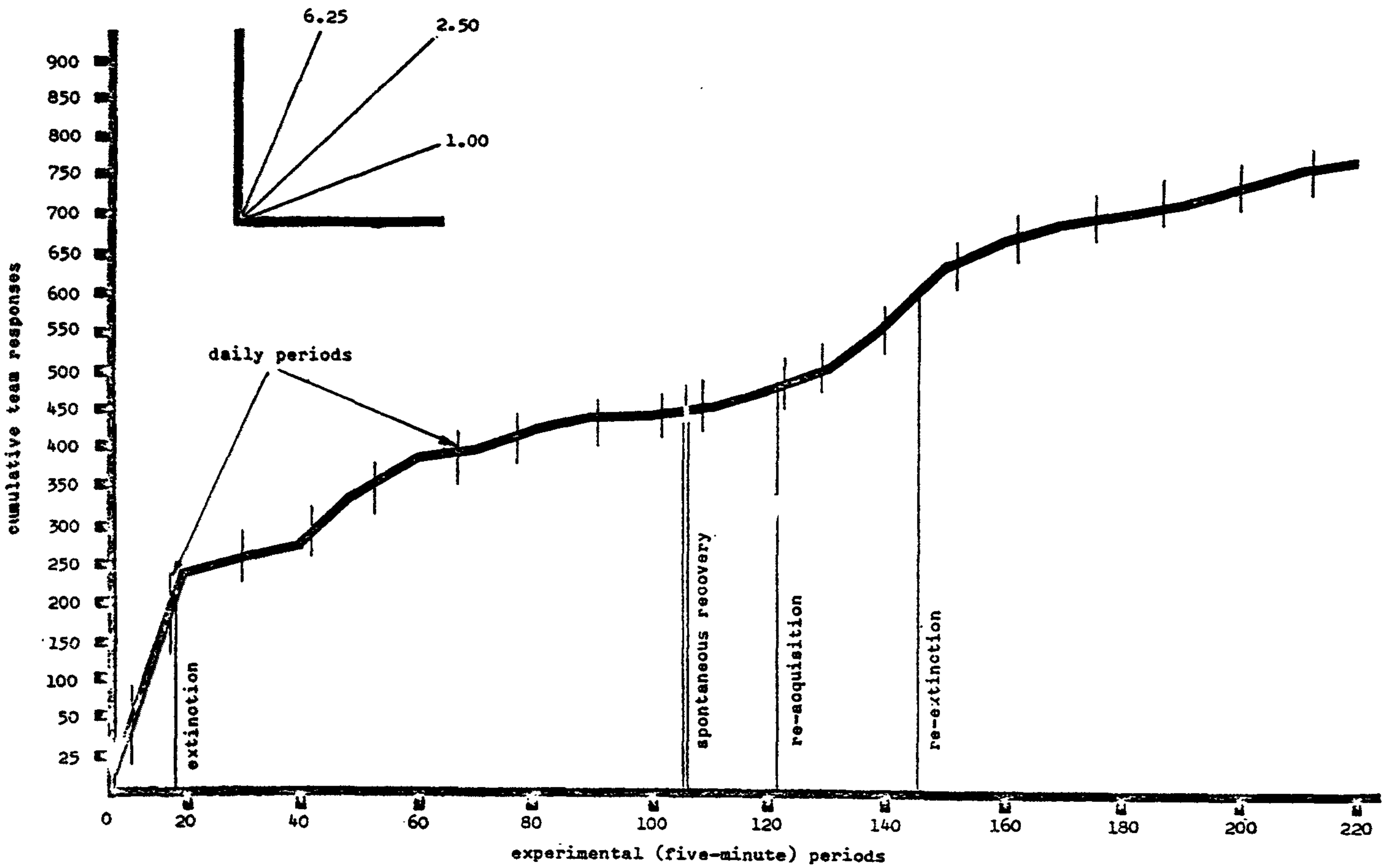


Figure: 10 Three-man team training: Team T-5

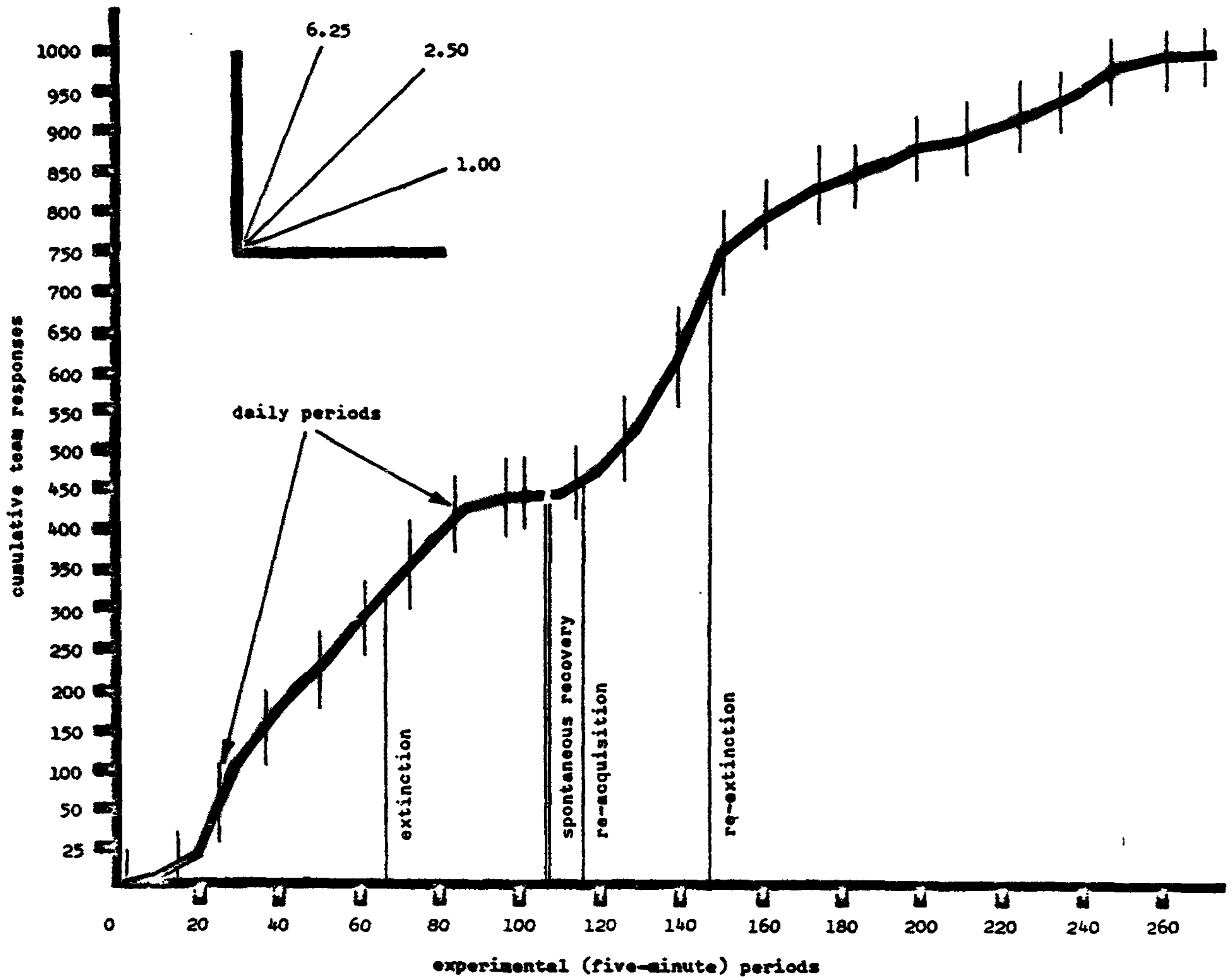


Figure: 11 Three-man team training: Team T-6

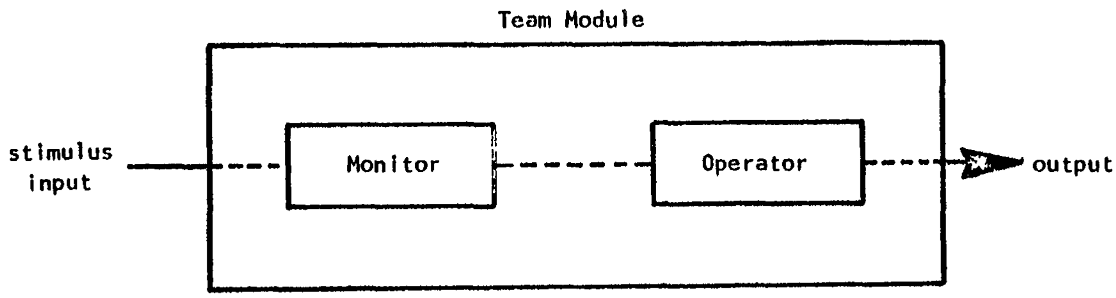


Figure: 12 Schematic of a two-man team

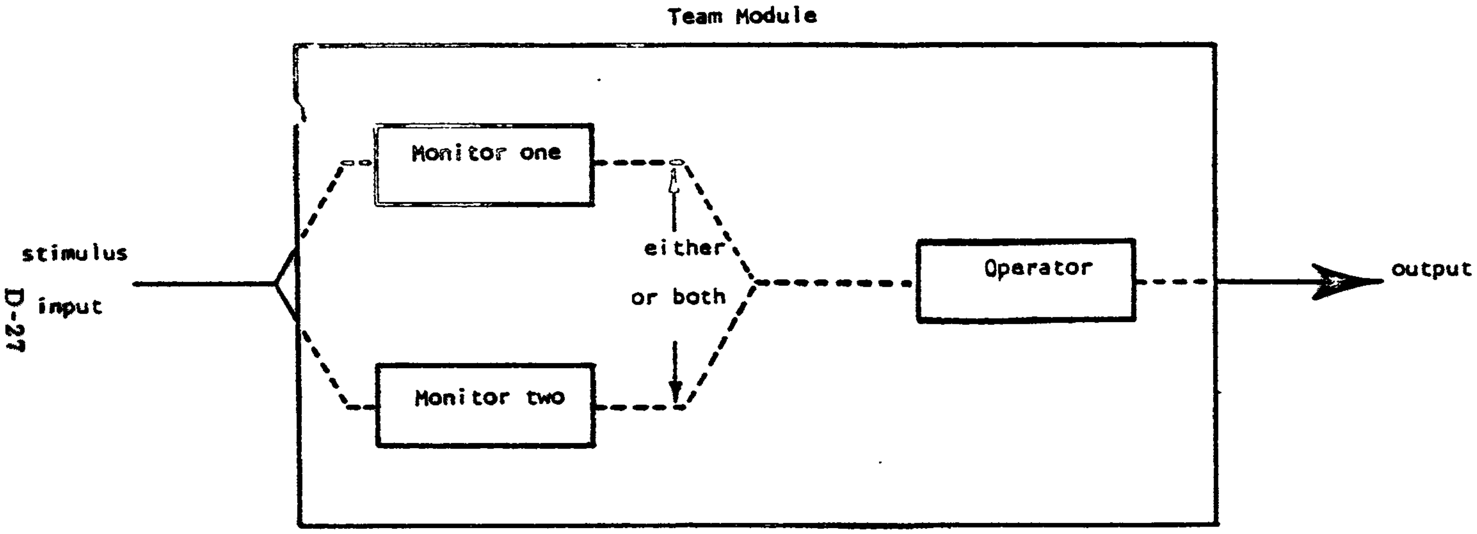


Figure: 13 Schematic of a redundancy team

Table 2

Phases, Titles, Descriptions, and Criteria of Training

Phase	Title	Description	Criterion
A	Preliminary Orientation	Introduction to Laboratory, signing of daily time sheets, assignment to panels, descriptive instructions about apparatus, etc.	None
B	Individual Training	Subjects practiced individually learning to make accurate two-second and four-second presses	Four consecutive five-minute periods of .63 (ratio of correct to total presses) proficiency for all individuals
C	Pattern Training	Monitor one and monitor two practiced making appropriate two-second and four-second presses to four different light patterns, for ten minutes (about 35 patterns)	None
D	Two-Man Team Training	Monitor one & operator, and monitor two & operator, of each team practiced as two-man components	Four consecutive five-minute periods of 15 <u>or more</u> team points for every two-man team
E	Redundancy Team Training	The three members of each team worked in a conjoint effort to score points	Four consecutive five-minute periods of ten <u>or fewer</u> team points

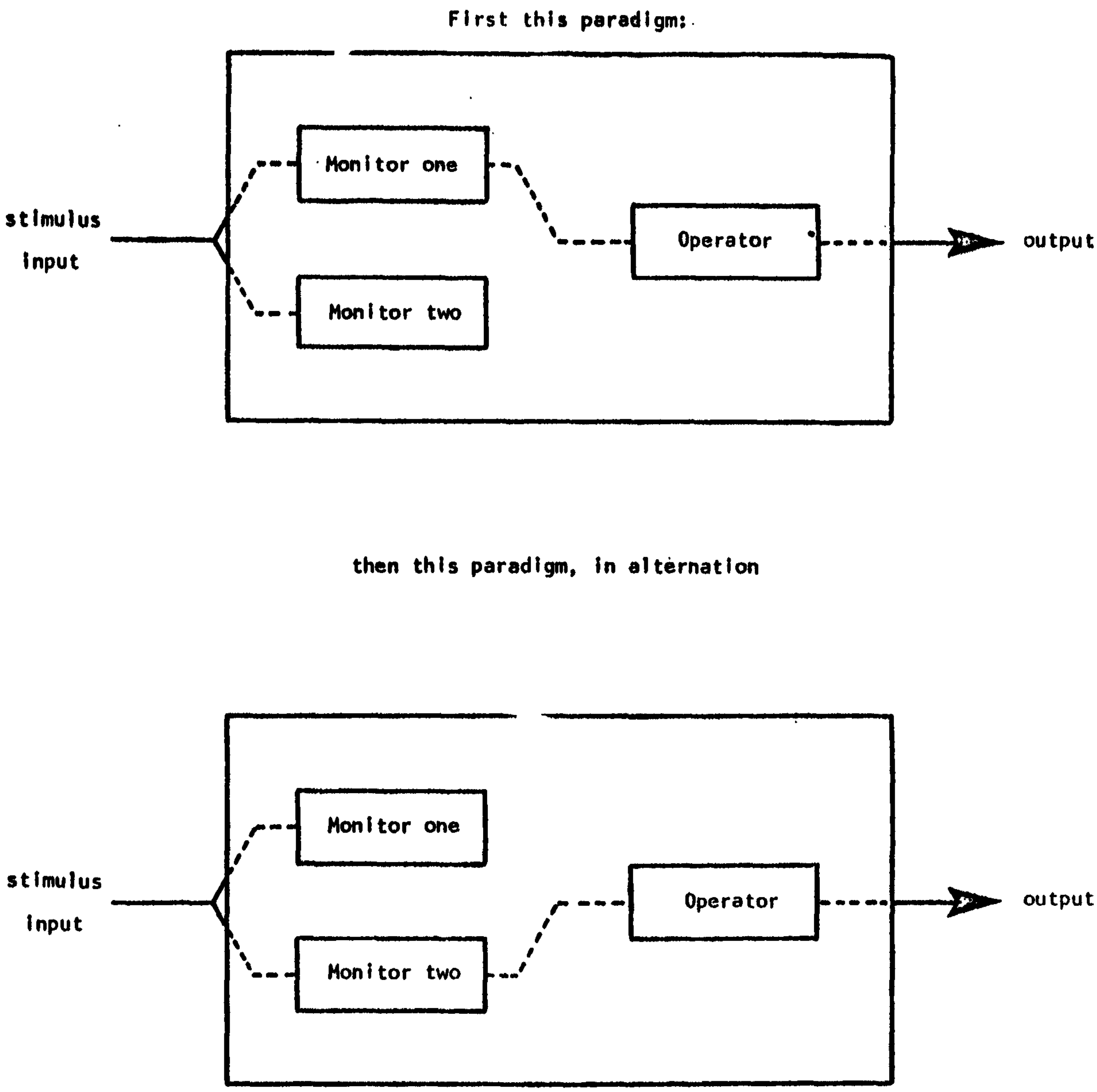


Figure: 14 Schematic of two-man team component training

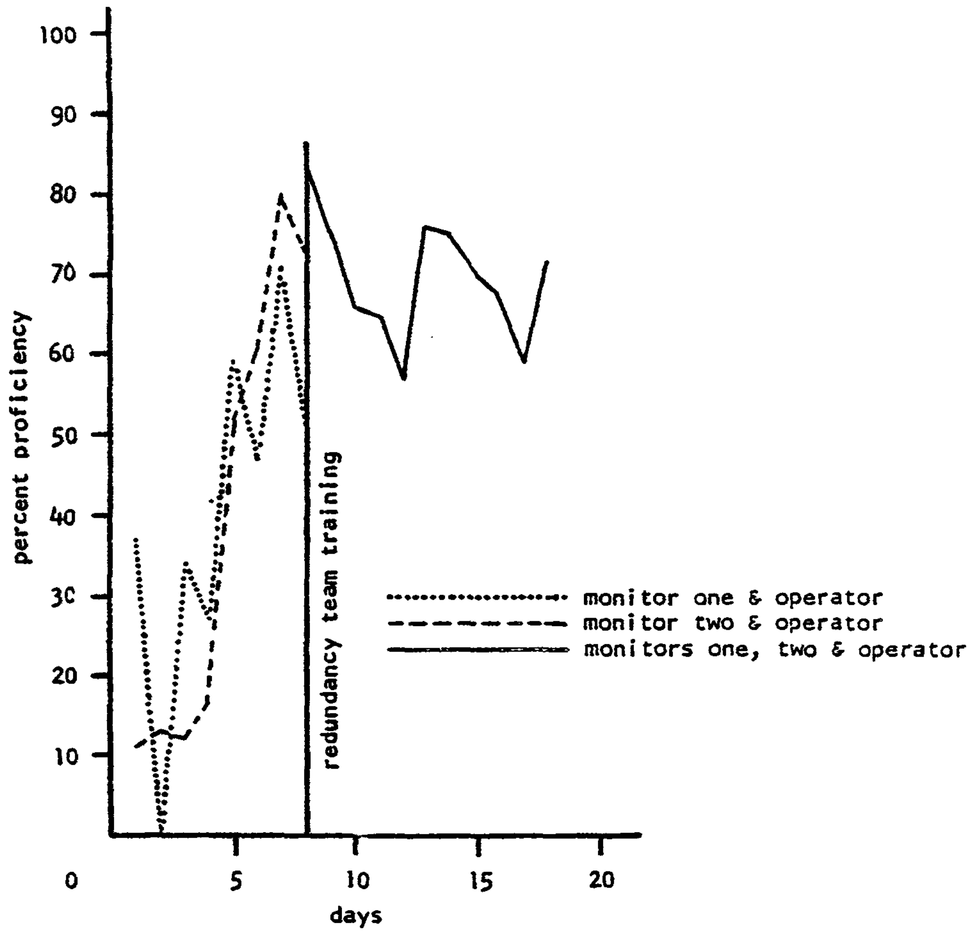


Figure: 15 Team 1: Two-man component and redundancy team proficiencies

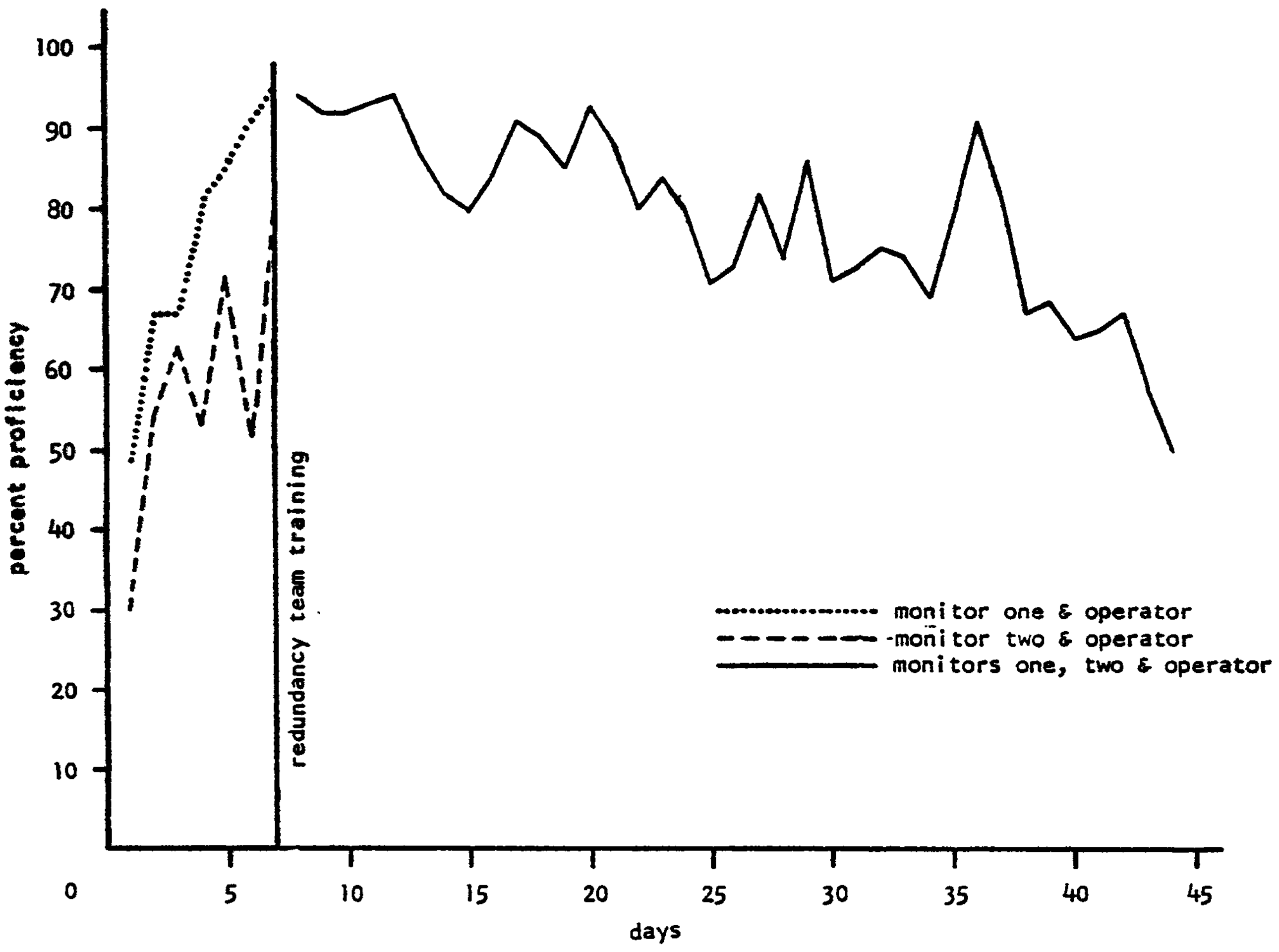


Figure: 16 Team 2: Two-man component and redundancy team proficiencies

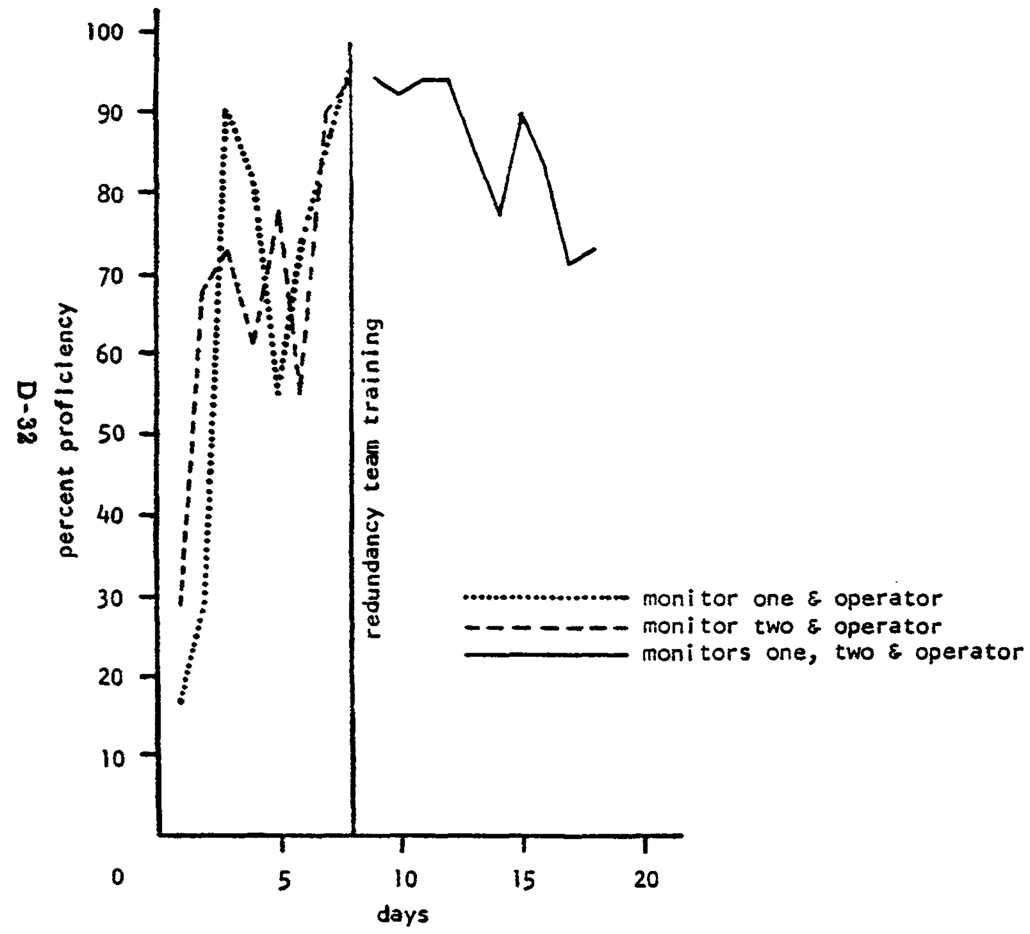


Figure: 17 Team 3: Two-man component and redundancy team proficiencies

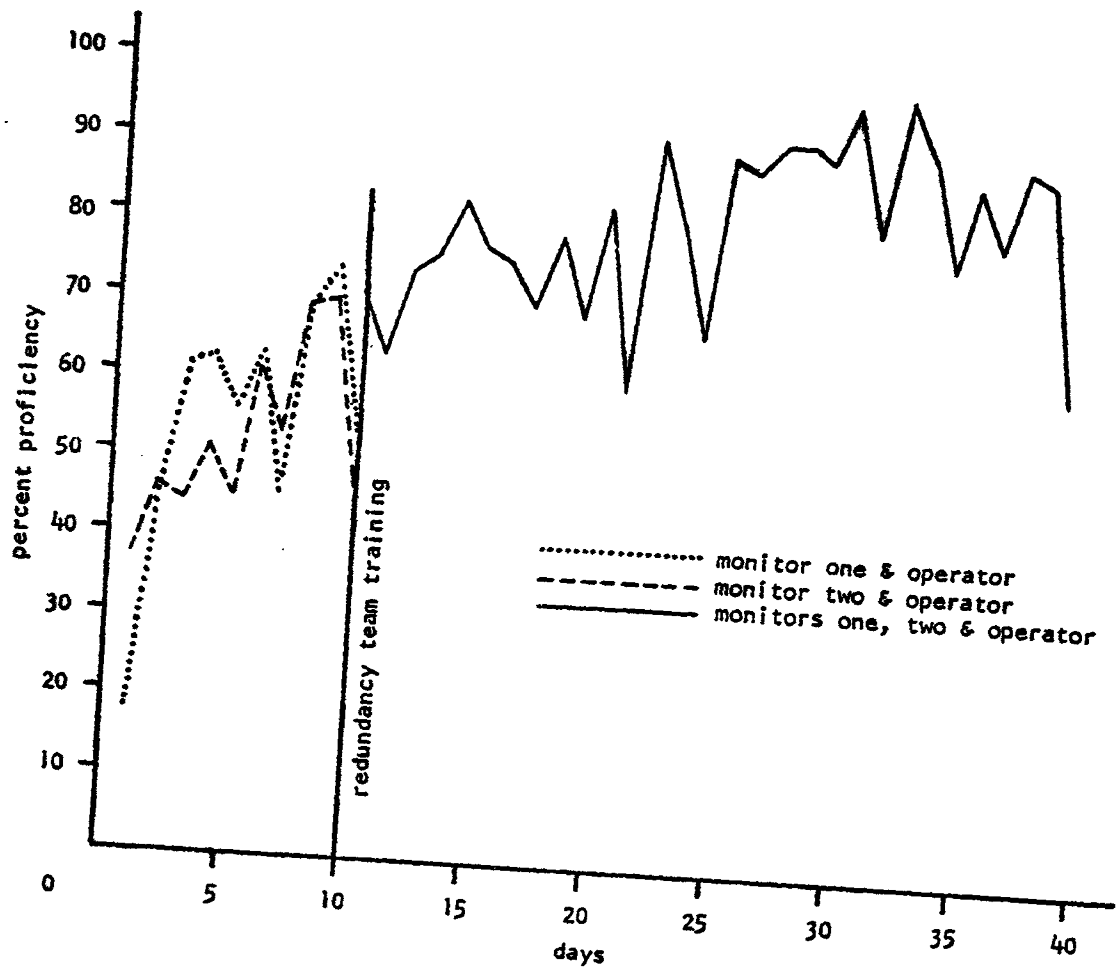


Figure: 18 Team 4: Two-man component and redundancy team proficiencies

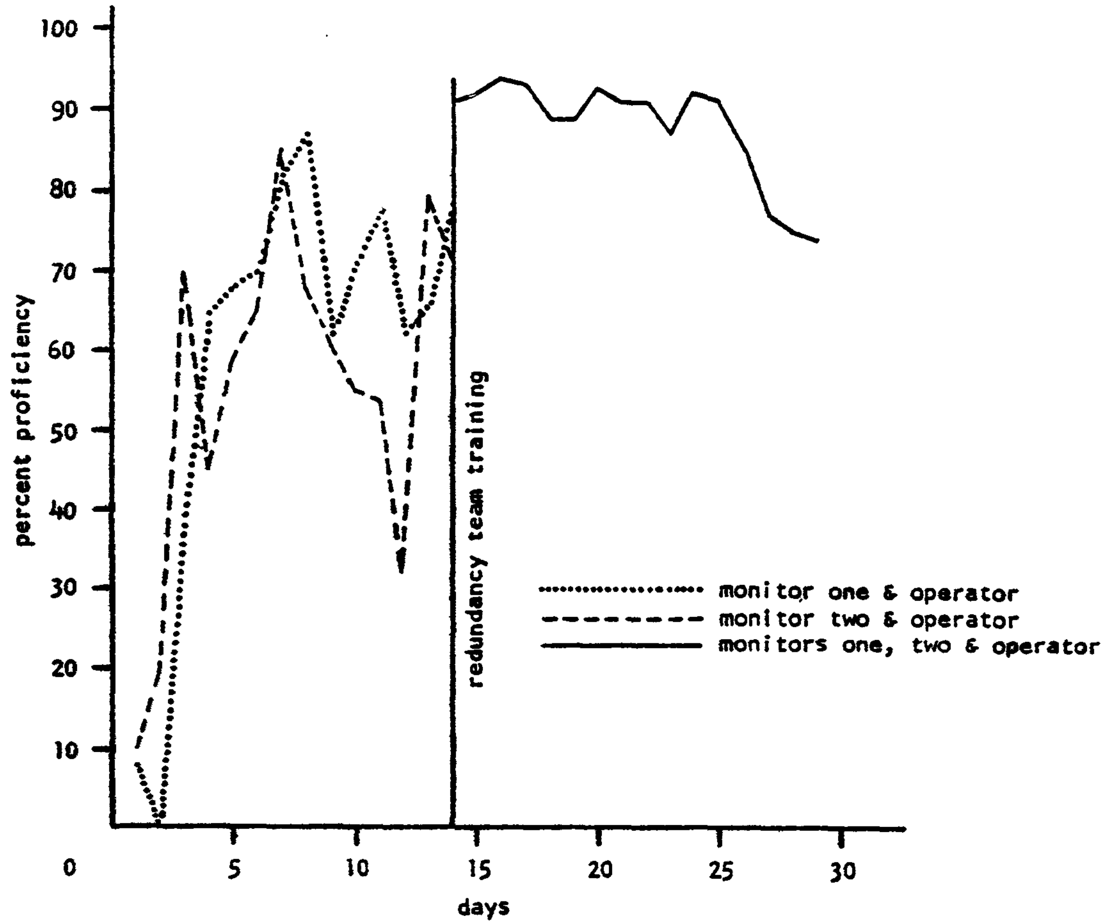


Figure: 19 Team 5: Two-man component and redundancy team proficiencies

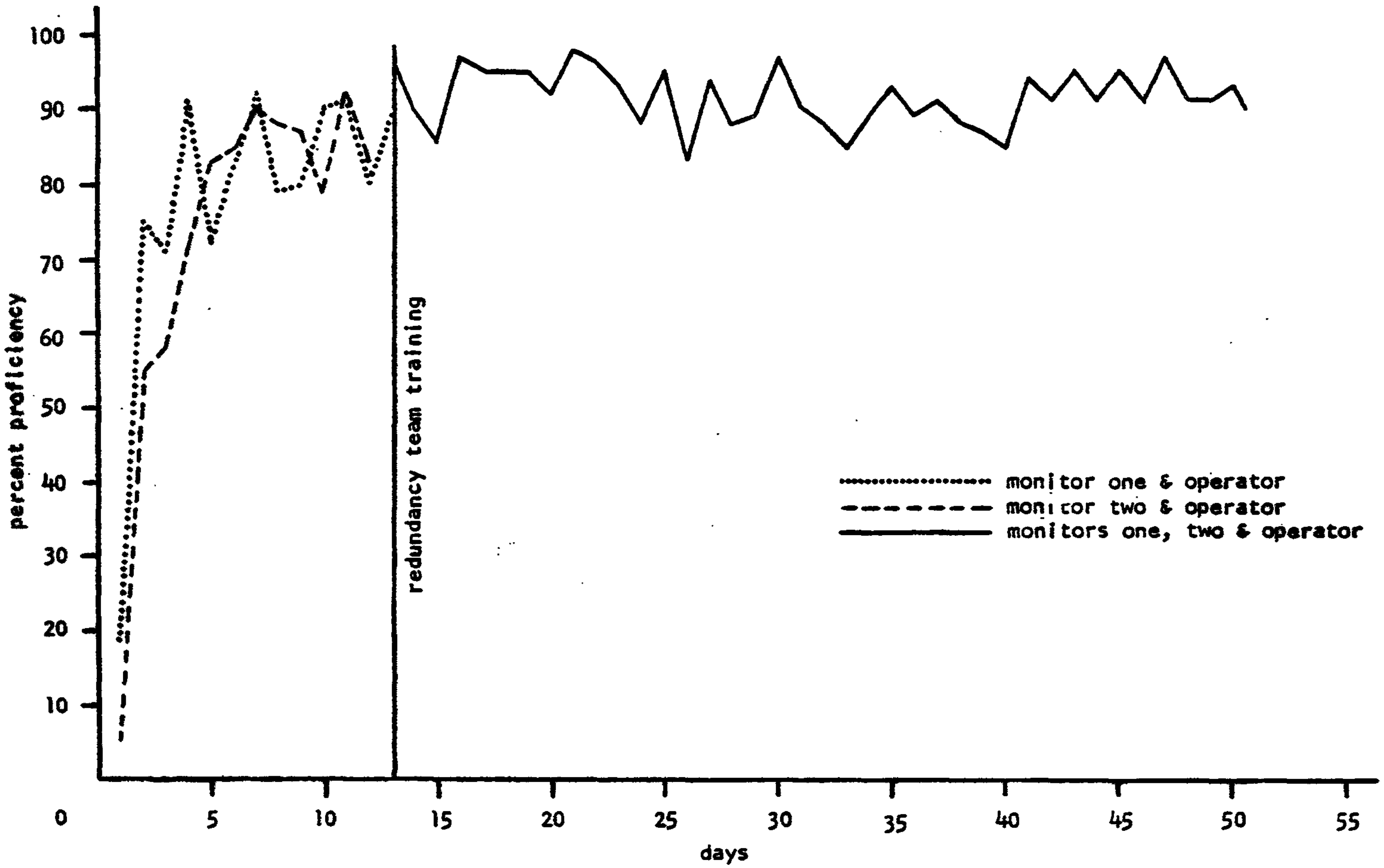


Figure: 20 Team 6: Two-man component and redundancy team proficiencies

Part II: Experimental Findings

David J. Klaus
American Institute of Research

As has just been described, we found we were able to study team performance in the Team Training Laboratory when the team was regarded as the module of investigation. Both reinforcement, or its absence, and the basic structure of the team were found to affect the acquisition, maintenance, and extinction of a team response. This represented the first phase of our research, determining the extent to which team performance in the laboratory could be observed and manipulated. Since then, a second phase of the research has been undertaken and a third phase has been initiated on a pilot basis. The experimental findings obtained from these studies suggest a number of variables which might be considered in future work on team performance.

The second phase of the research consists of efforts to control the outcomes of team training by further analyzing and varying structural, individual member, and procedural factors which might affect team performance. Thus far, three studies have been initiated for this purpose. The first of these was conducted by Karl Egerman as his doctoral dissertation. The purpose of the study was to investigate the relationship between team structure and the course of individual member performance as it was affected by the appropriateness or inappropriateness of team reinforcement during team training. From the description of the team paradigm already given, it should be clear that whether or not a team member experiences reinforcement, either appropriate or not appropriate, depends upon the performance of the other members of the team and upon the conditions under which team reinforcement will be supplied. Thus, the schedule of reinforcement experienced by each team member for both correct and incorrect responses is a function of the contribution of his responses to team success and the relationship between team success and the response he made on that trial.

In this study, three types of teams were investigated. Each team was composed of two members who were given a constant amount of pre-training on the timing response before being assembled into teams. The first type of team was the series team; in a series team, both members had to be correct for a team reinforcement to follow. Under these circumstances, each team member experienced reinforcement for only some of his correct responses but he never experienced reinforcement for any of his incorrect responses. For a member of a series team, then, appropriate reinforcement is aperiodic and non-appropriate reinforcement does not occur. The second type of team was the parallel team; in a parallel team, only one member has to be correct for a team reinforcement to follow. Under these circumstances, each team member experienced reinforcement for all of his correct responses but he also experienced occasional reinforcement for some of his incorrect responses. For a member of a parallel team, then, appropriate reinforcement is continuous and non-appropriate reinforcement is aperiodic. The third type of team was the individual team; in an individual team, the occurrence of a team reinforcement depends solely upon the performance of one member, while the performance of the other member is not considered. Under these circumstances, the "team" member experiences appropriate reinforcement for both his correct and incorrect responses, while the "non-team" member experiences aperiodic reinforcement both for his correct and incorrect responses.

Several predictions can be made concerning team and individual member performance under these various conditions. First, knowing the hypothetical probability of a correct team response in each of these three arrangements and knowing the proficiency of the individual members prior to entering team training, it should be possible to predict the proportion of correct team responses during the initial stages of team training. This is illustrated in Figure 21. Second, it should be possible to predict the relative number of correct responses made by each member during the course of training based upon a knowledge of his predicted schedule of reinforcement;

e.g., continuous appropriate reinforcement is the most favorable schedule, as further refined by a knowledge of individual pre-team member proficiencies. Finally, it should be possible to predict the course of team proficiency over a period of team performance on the basis of knowing the reinforcement schedules experienced by the members of a particular type of team.

Six teams of each type, series, parallel, and individual, were studied for 130 five-minute periods spaced over several days using an experimental procedure similar to those already described. The findings of the study were, first, initial team performance and performance predicted from arrangement and member proficiencies correlated .73; second, the ranked performance of team members correlated .94 with ranks predicted on the basis of member proficiencies prior to team training and arrangement-influenced schedules of reinforcement; third, the influence of different schedules of reinforcement on the course of team performance is shown in Figure 22 which describes the drop in performance attributable to inappropriate reinforcement for incorrect responding.

Some typical performance curves obtained from each of the three types of teams are shown in Figures 23 - 25 on the following pages. Notice that team proficiency is necessarily less then individual proficiency in the series teams, necessarily greater in the parallel teams, and equal to the "team" member curve for the individual teams. Notice, also, the tendency for the performance curve of parallel teams to show a decrease in proficiency with time and the tendency for one member to extinguish. In two of the individual teams, the "non-team" member managed to maintain proficient performance throughout the experiment despite completely inappropriate reinforcement. This was felt to be due to the high level of entering proficiency for these members.

The next study undertaken was an attempt to define some of the parameters of individual member characteristics and training conditions which might influence the acquisition and extinction of a team response.

As shown in Figure 26, 28 three man series teams were studied in a multivariate design which simultaneously investigated entering member proficiency (high, medium, and low), member ability (fast learners and slow learners), training delays (immediate or delayed initiation of team training), and team structure (members apart or together in proficiency). All teams were under continuous reinforcement during acquisition and then were placed on extinction after meeting a uniform proficiency criterion.

Seven of the 28 teams failed to reach the acquisition criterion after 300 five-minute periods. Most of these were low teams, where the probability of a correct team response, computed on the basis of entering member proficiency, was so low that an "extinction ratio" was in effect; i.e., ex tinction occurred in spite of occasional reinforcement because there was not a sufficient number of reinforcements to maintain the response. The probabilities of a correct team response, in terms of the parameters studied, are shown in Figure 27. Trials to acquisition are shown in Figure 28, and trails to extinction are shown in Figure 29 following. The low teams required more trials to reach criterion and more trials for extinction to occur. Figure 30 shows the number of trials required for the first 100 correct responses. This is, perhaps, a more sensitive measure of team learning than the acquisition of a performance criterion.

From the evidence obtained, two factors seem to influence team performance. First, individual member proficiency, or level of attainment, is an important determiner of team learning; acquisition is substantially more rapid in teams composed of high proficiency members, as would be expected, on the basis of the probability of a correct team response. Second, teams composed of slow learners tend to have more rapid acquisition, especially early in team training, than teams composed of fast learners. This is probably due to the experience they have had with intermittent reinforcement. We have detected a dip in team performance early in the training of series teams which reflects a switch in the ratio of reinforcement experienced by the team members. Some experience with low or intermittent schedules during individual training seems to facilitate later team training. Perhaps the football coach is correct after all; with ample practice, slow learners are likely to result in a highly proficient team.

The third study, which is now in progress, is an attempt to accelerate team acquisition by the use of a simulated supervisor early in team training. In our early analysis of team learning, we hypothesized that the role of a supervisor was that of supplying reinforcement to individual team members which was independent of the success or failure of the team as a whole. In other words, this was the "pat-on-the-back" needed to maintain individual proficiency during periods when the team was not successful enough to produce sufficiently frequent reinforcements. As was just noted, this is especially likely early in team training and with teams composed of members at low levels of entering proficiency.

In this study, 18 three-man series teams are being trained; six teams are composed of low proficiency members, six of medium proficiency members, and six of high proficiency members. Three of the teams in each proficiency group are being trained as in previous studies. The remaining teams are required to reach acquisition criterion twice; first, with individual reinforcement supplied to each team member on the basis of the correctness of his response in addition to the team reinforcement supplied to the team as a whole for a correct team response; and a second time, without individual reinforcement. We predicted that the experimental teams would reach the team performance criterion faster than the control teams, even though they had to reach it twice, and that the effect would be more pronounced for low teams than for high teams.

Nine of the 18 teams have been completed and three others are currently in progress. Thus, the findings are quite tentative but well worth repeating because they point out the surprise factor in team research. The experimental teams do not seem to be attaining final criterion any more rapidly than control teams, regardless of the proficiency of the members. On the other hand, the experimental teams seem to develop a substantially greater resistance to extinction than the control teams and this is more pronounced in teams with high-proficiency members than in teams with low-proficiency members. We intend to delay suggesting explanations for these results until we learn whether or not the data from the remaining teams in the study substantiate these tentative findings.

The third phase of research in the Team Training Laboratory has been the study of simulated teams, where one individual is subjected to the conditions he would experience had he been a member of a team. As more and more is learned about the factors influencing team performance, it should be possible to test a number of important hypotheses relating to the effects of a team environment on individual performance and, in turn, the effects of changes in individual proficiency on team output. Only one investigation has been conducted thus far using simulated teams. This was a pilot study designed by Jerry Short.

The hypothesis investigated in this study is illustrated in Figure 31. Using the theorem of probability applicable to series team performance, it is possible to calculate that only on 60% of the instances when man A in a two-man team is correct will the team be reinforced; in other words, man A will experience reinforcement only for 60% of his correct responses in a two-man team. In a five-man team, man A will be reinforced only for 13% of his correct responses. In the study, nine individuals were trained until their pre-team proficiency stabilized. They were then switched to a simulated team condition in which their correct responses were reinforced according to a hypothetical schedule computed on the basis of the number of members in the simulated team. Figure 32 shows the result. For either type of team, the difference in proficiency between the end of individual and the beginning of team training is significant. Also, on the average, recovery of pre-team proficiency was more likely in the two-man than five-man teams so that there was a significant difference in the over-all proficiency of members of the two- and five-man teams.

In summary, the study of teams as the modules of investigation and reinforcement contingencies have both proven to be fundamentally sound approaches in a series of laboratory investigations. Several findings have been obtained, such as those on team-member redundancy, team composition, and the difficulty in switching from individual to team training conditions, which could be applied to non-laboratory teams for verification. Even more important, it has been possible to define a team in such a way as to develop a conceptual framework which has considerable promise for the further investigation of the performance of multi-man systems.

TTL

Study IV: Example

IF $P_A = .50$ AND $P_B = .75$

SERIES $.50 \times .75 =$ **.38**

PARALLEL $.50 + .75 - (.50)(.75) =$ **.87**

INDIVIDUAL $.50 =$ **.50**

TEAM OUTPUT

Figure 21: Team output in three arrangements.

INITIAL AND FINAL AVERAGE TEAM PROFICIENCIES, DIFFERENCES, AND STATEMENT OF THE SCHEDULE OF REINFORCEMENT IN SERIES, PARALLEL, AND INDIVIDUAL TEAM ARRANGEMENTS

Team Arrangement	Five-Minute Periods Initial Ten	Five-Minute Periods Final Ten	Difference	Reinforcement Schedule
Series	46.68%	48.83%	2.15%	Aperiodic Reinforcement for Correct Responses
Parallel	84.50	71.50	-13.00	Continuous for Correct, Aperiodic for Incorrect Responses
Individual Team Component	68.67	70.33	2.50	Continuous for Correct Responses
Non-Team Component	64.33	38.50	-25.66	Aperiodic for Both Correct and Incorrect Responses

Figure 22: Initial and final team proficiencies.

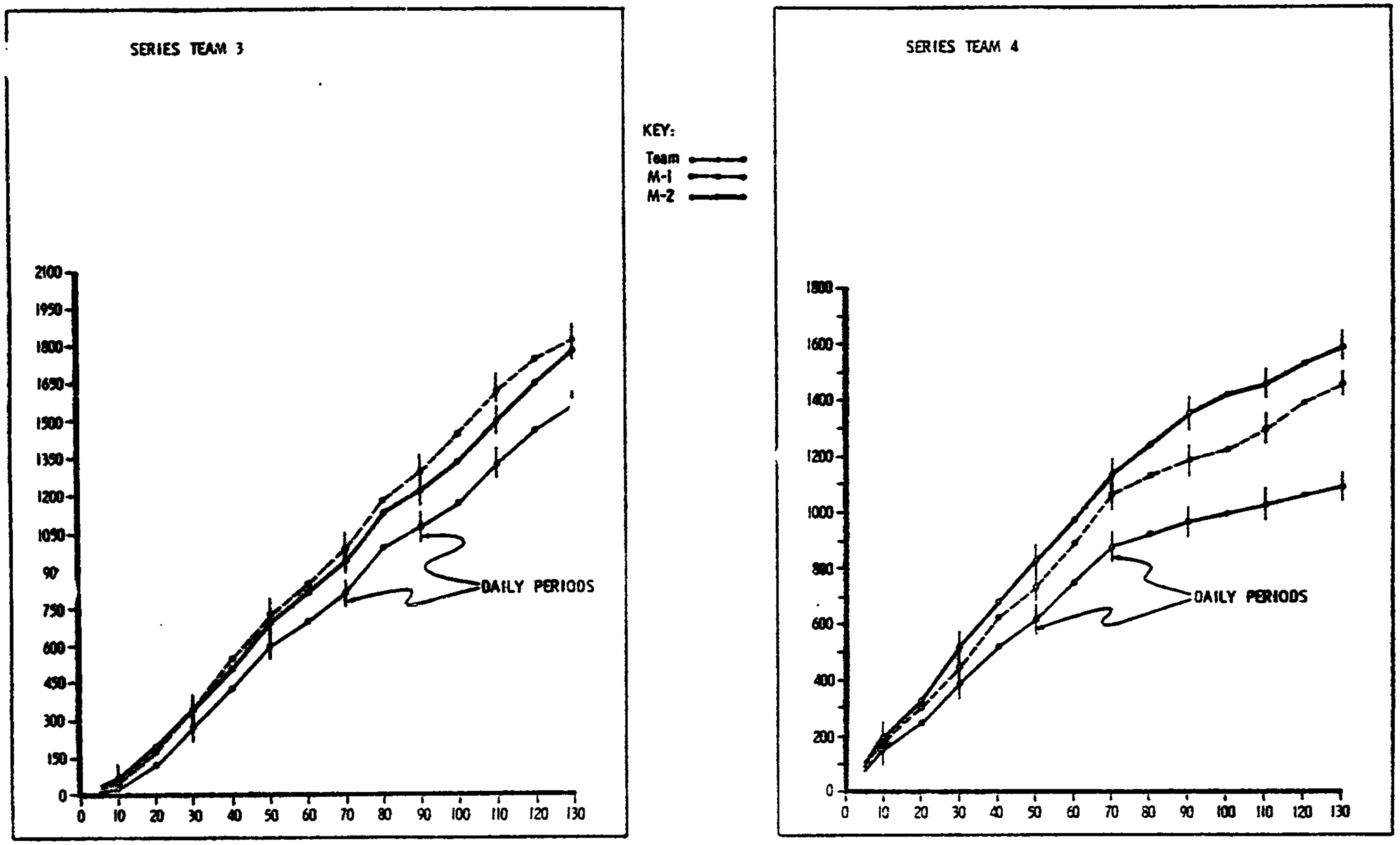


Figure 23: Two sample series teams (Teams 3 and 4).

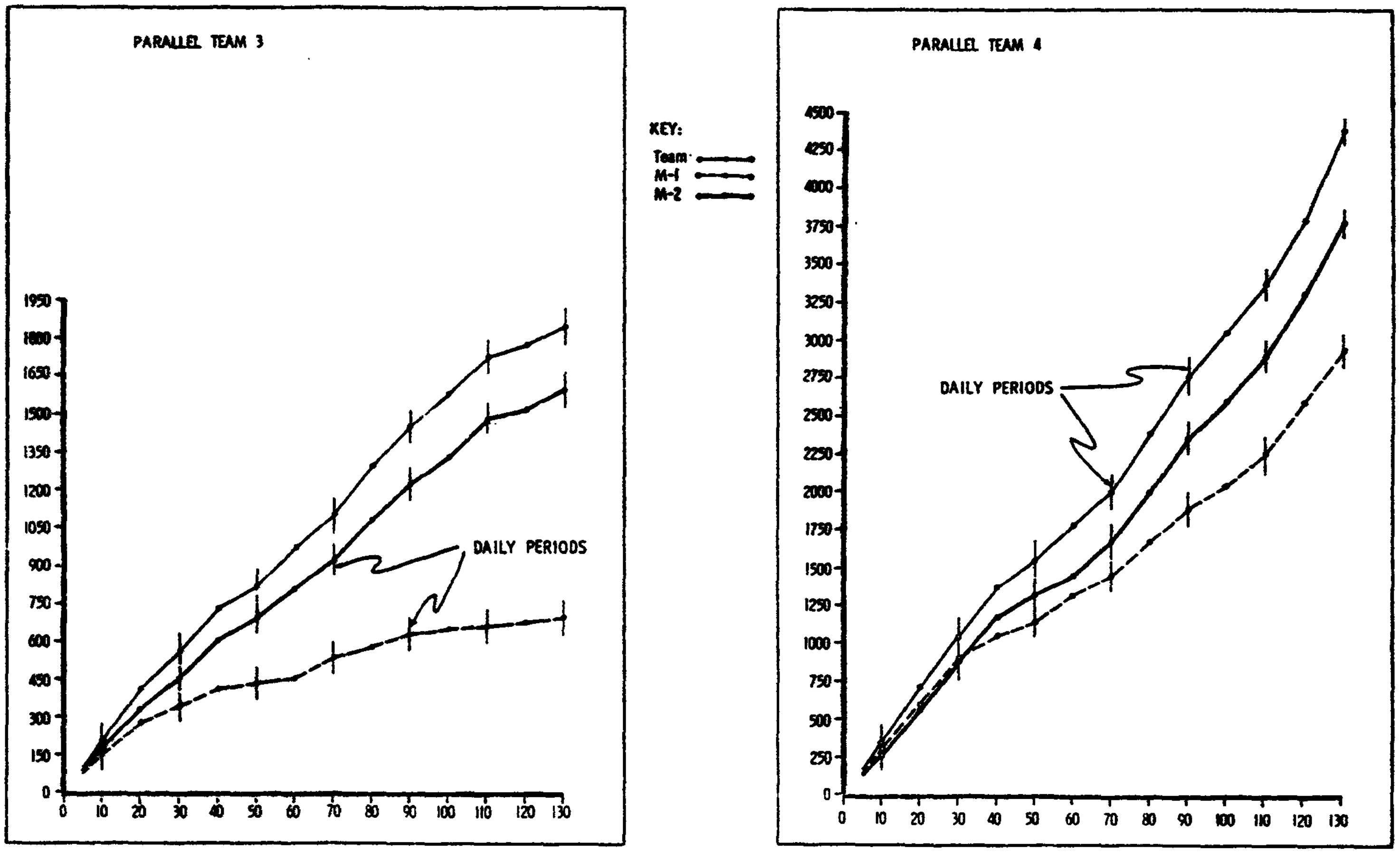


Figure 24: Two sample parallel teams (Teams 3 and 4).

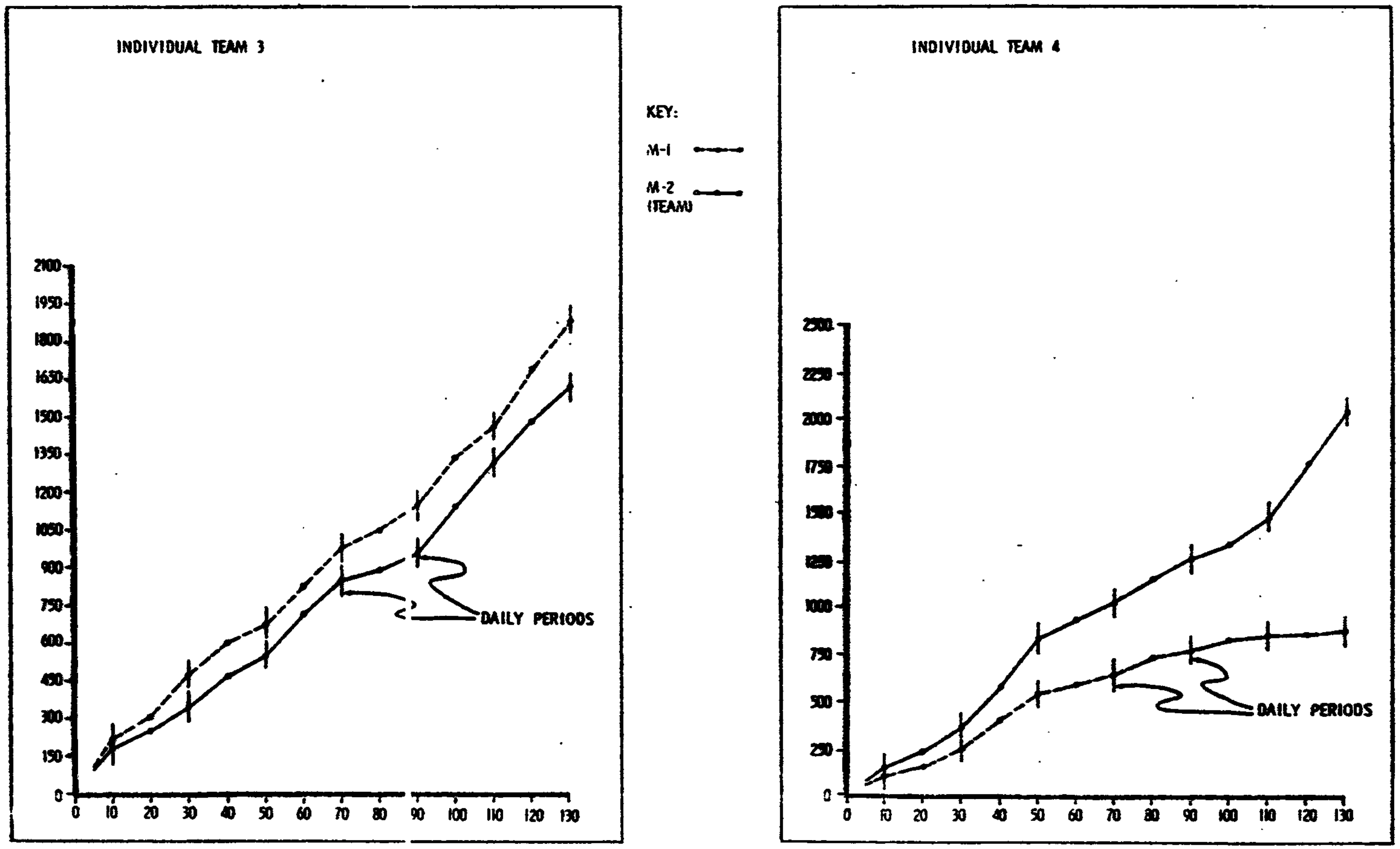


Figure 25: Two sample individual teams (Teams 3 and 4).

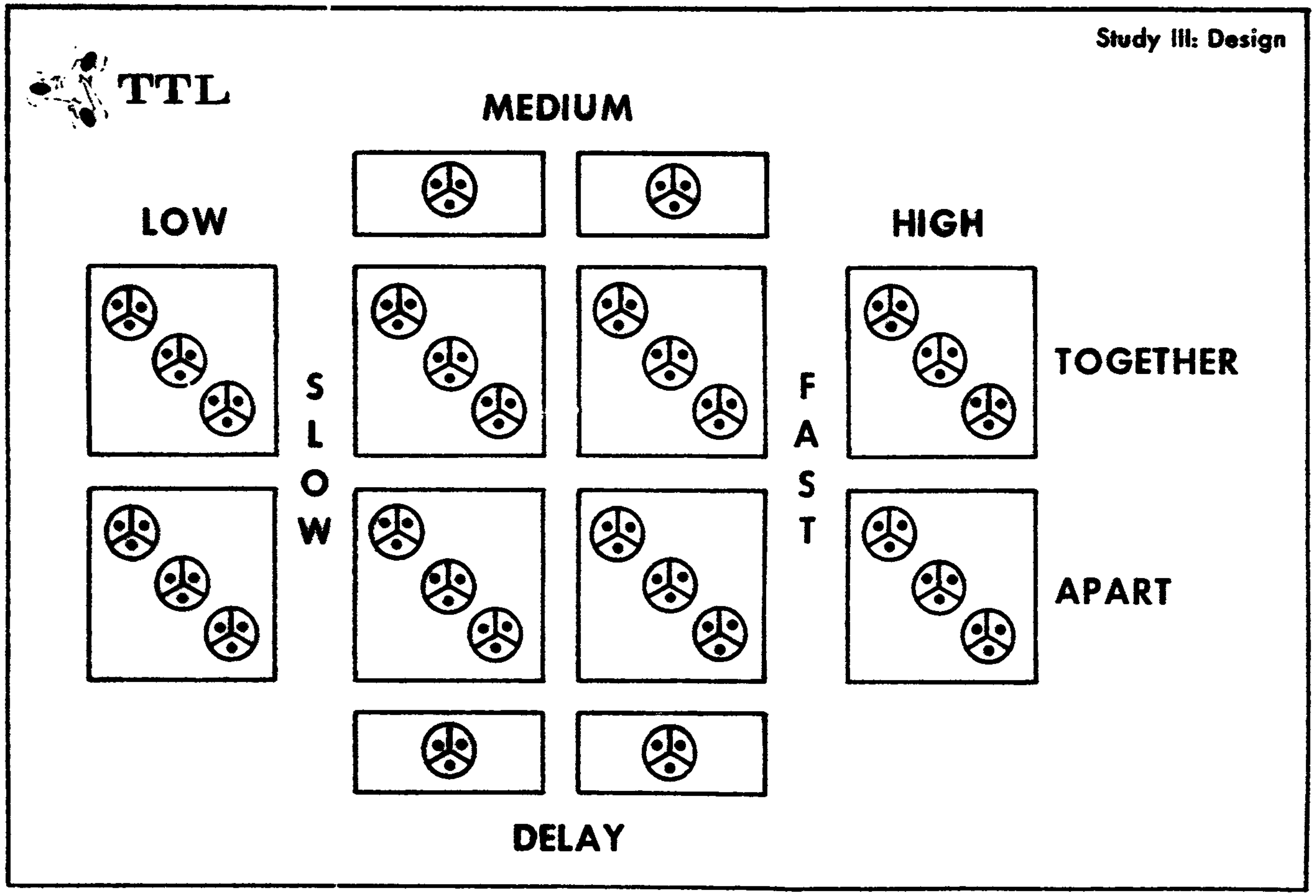


Figure 26 :Design of experiment on parameters of team performance.

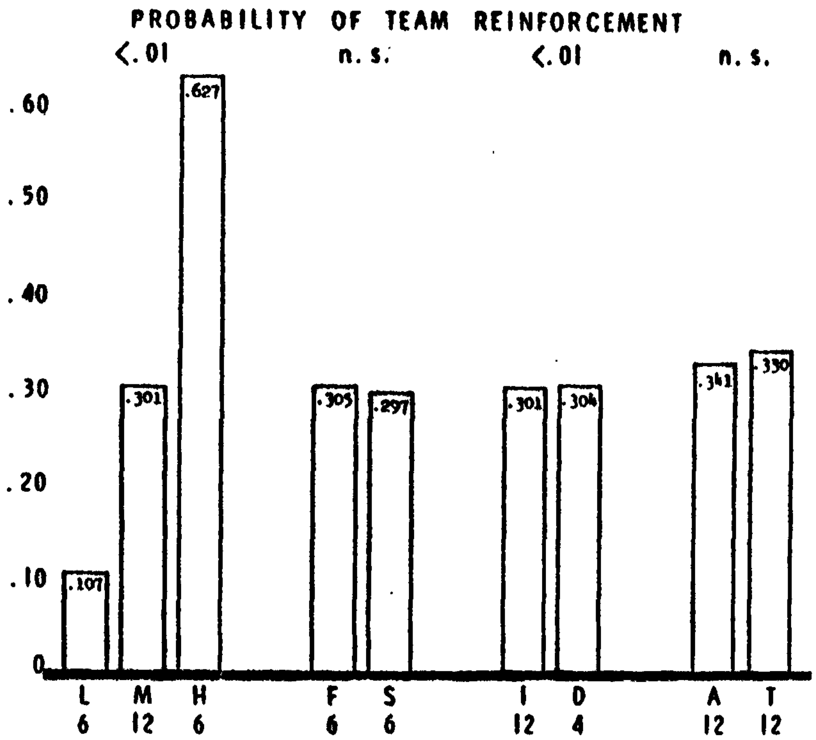


Figure 27: **Probability of team reinforcement in Parameter Study.**

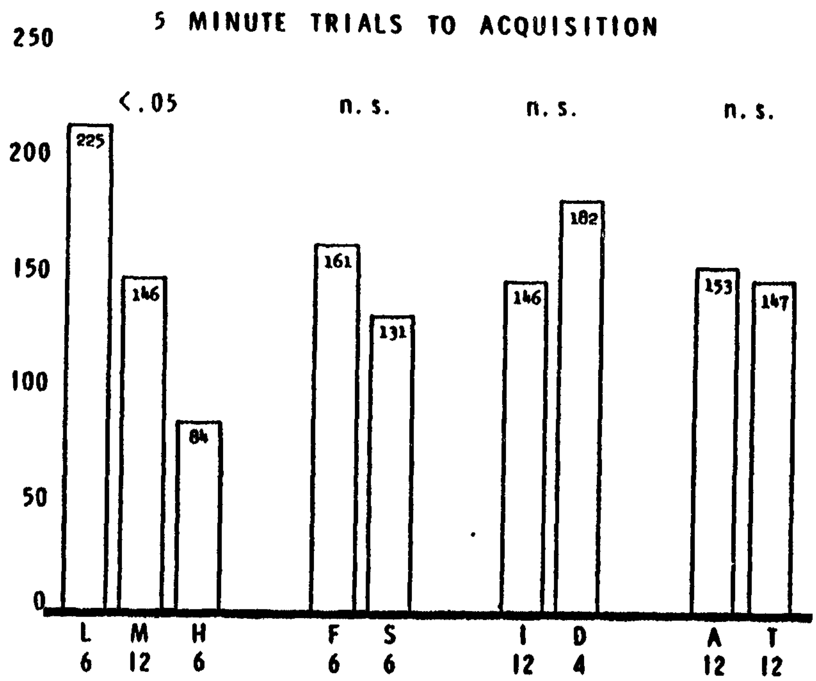


Figure 28: **Five-minute trials to acquisition in Parameter Study.**

TRIALS TO EXTINCTION

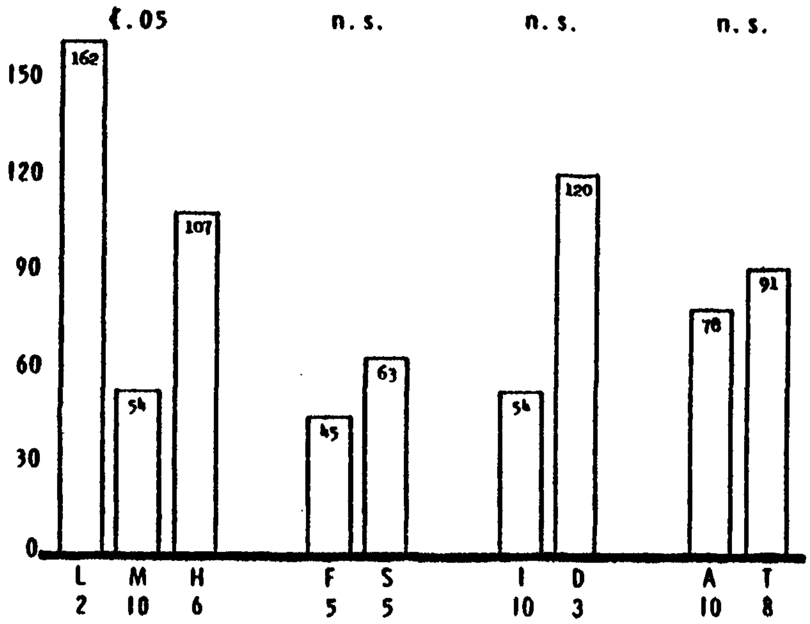


Figure 29: **Five-minute trials to extinction in Parameter Study.**

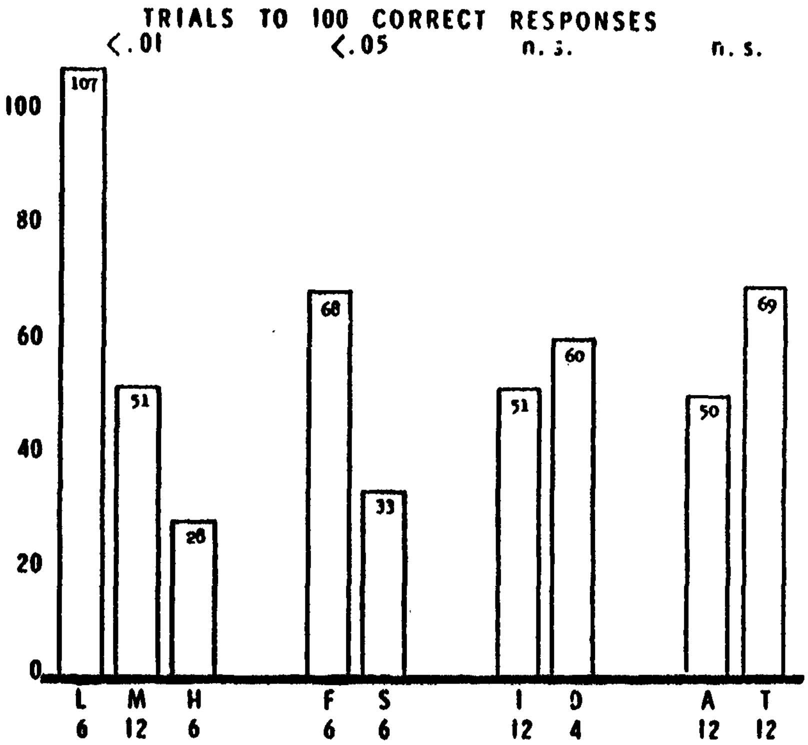


Figure 30: **Five-minute trials to 100 correct responses in Parameter Study.**

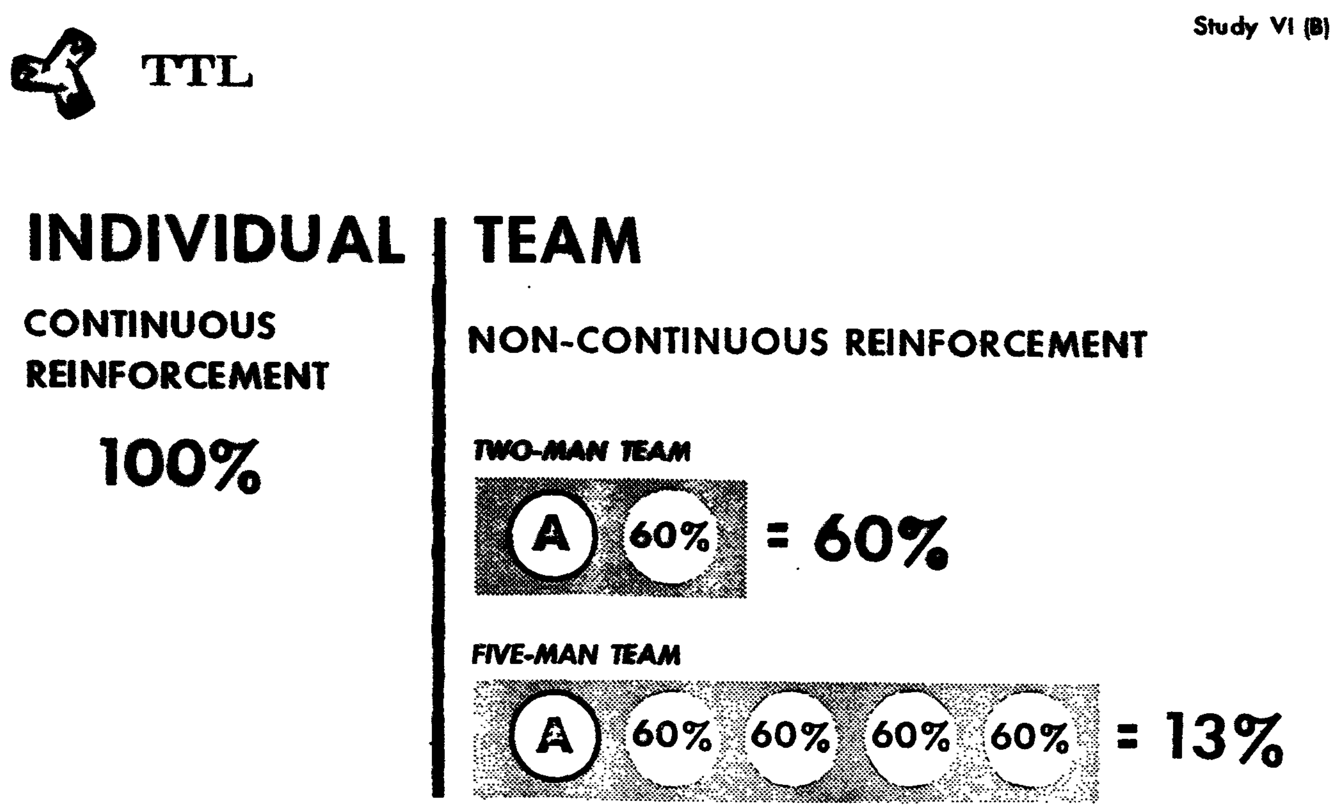


Figure 31: Probability of reinforcement for correct responses in simulated teams.

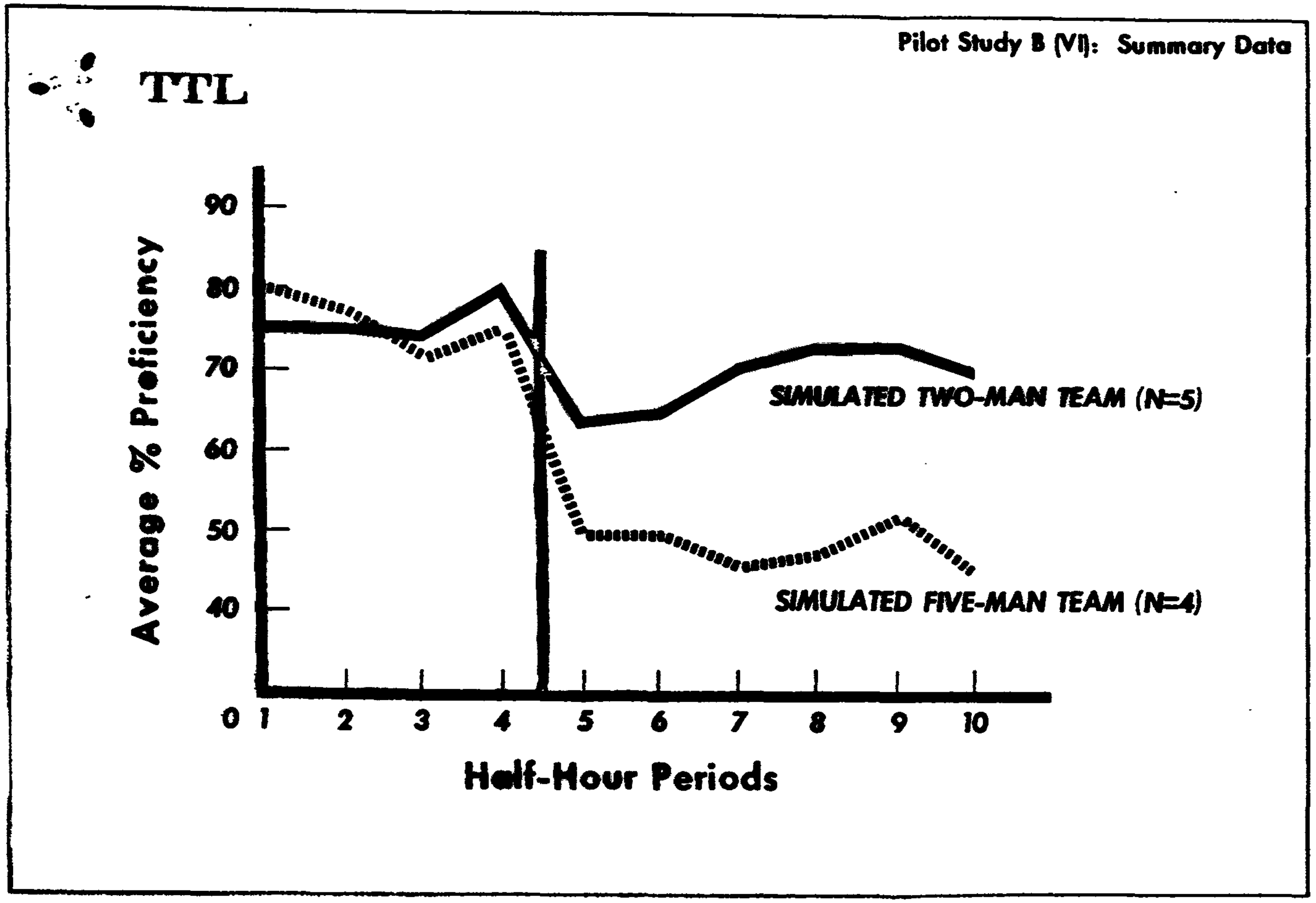


Figure 32: Data from two-man and five-man simulated teams.

INCREASING TEAM PROFICIENCY THROUGH TRAINING

A Bibliography

Reports distributed and papers presented on team training based upon research conducted under the sponsorship of the Office of Naval Research, Contract: Nonr 2551(00), Glenn Bryan, Monitor, Robert Glaser, Principal Investigator, David J. Klaus, Project Director.

Klaus, D. J., & Glaser, R. Studies of Navy guided missile teams. Pittsburgh: American Institute for Research, December 1958.

Glanzer, M., & Glaser, R. Techniques for the study of group structure and behavior: I. Analysis of structure. Psychol. Bull., 1959, 56, 317-332.

Klaus, D. J., & Glaser, R. Increasing team proficiency through training. 1. A program of research. Pittsburgh: American Institute for Research, December 1960.

Glanzer, M., & Glaser, R. Techniques for the study of group structure and behavior: II. Empirical studies of the effects of structure in small groups. Psychol. Bull., 1961, 58, 1 - 27.

Glaser, R., & Klaus, D. J. Laboratory studies of team training. Paper presented at the meetings of the Eastern Psychological Association, April 1961.

Egerman, K., Klaus, D. J., & Glaser, R. Decremental effects of reinforcement in teams with redundant members. Paper presented at the meetings of the American Psychological Association, September 1961.

Glaser, R., Klaus, D. J., & Egerman, K. Increasing team proficiency through training. 2. The acquisition and extinction of a team response. Pittsburgh: American Institute for Research, May 1962.

Egerman, K., Klaus, D. J., & Glaser, R. Increasing team proficiency through training. 3. Decremental effects of reinforcement in teams with redundant members. Pittsburgh: American Institute for Research, June 1962.

Klaus, D. J., & Glaser, R. Team learning as a function of member learning characteristics. Paper presented at the meetings of the Eastern Psychological Association, April 1963.

Egerman, K., & Glaser, R. A learning-theoretic analysis of the effects of team arrangement on team performance. Paper presented at the meetings of the American Psychological Association, August 1963.

Short, J. G., Glaser, R., & Klaus, D. J. The effect of a simulated team environment on individual performance of a timing task. Paper presented at the meetings of the American Psychological Association, August 1963.

Egerman, K., Glaser, R., & Klaus, D. J. Increasing team proficiency through training. 4. A learning-theoretic analysis of the effects of team arrangement on team performance. Pittsburgh: American Institute for Research, September 1963.

A CONCEPT FOR IMPROVING PERSONNEL READINESS

Joseph Rigney
Electronics Personnel Research Group
University of Southern California

Preface

For a number of years, we have had opportunities to examine the Navy's personnel readiness situation from several points of view. These opportunities have ranged from extensive shipboard observations to formal scientific analyses. As a consequence, and more or less unexpectedly, a concept has suggested itself as a new approach to chronic personnel readiness problems. The basic notion occurred over eight years ago, while the authors were involved in an analysis of future anti-air warfare personnel problems. It has been very persistent. Despite clearly foreseeable obstacles to implementation, the concept lingers on. In an effort to arrive at a conclusion about its validity, and at the same time to describe it to those in the Navy who may be interested, the following material has been prepared.

It is hoped that you will consider it fairly and will react to it honestly. We are particularly interested in learning about parts of it that you have difficulty in understanding. Also, since this is an effort to exhaust possible functions which might be assigned to a vehicle designed to implement the concept, we welcome additions to the list.

I. PERSONNEL READINESS PROBLEMS

Although fleet tactical capabilities have been strengthened by new weapon systems, the readiness to employ these systems, as well as to maintain them, continues to be a matter of concern. In these areas, many factors limit the effectiveness of man-machine combinations to operate and to maintain new weapon systems, with the result that the operational capabilities of these systems fall far short of expectations. Shortcomings of the existing systems are well known. Several of the frequent complaints stem from the following factors.

1. First-Enlistment Technicians.

This has been a chronic problem since at least the days of World War II. Although there may have been brief intervals since then when the supply of highly proficient technicians was adequate, the general trend has been one of short supply. In view of this, the obvious assumption to make is that the U.S. Navy will have to depend upon the first-enlistment technician for operating and maintaining its equipment into the foreseeable future. The constraints which this condition places upon the training and utilization of personnel are well known.

2. Wild Fluctuations in Crew Proficiency.

The deployment cycle of ships is accompanied by a personnel cycle in which the crew of any one ship varies from reasonably experienced and proficient to "green" men who have had little or no shipboard experience and whose training may be quite sketchy. Ships returning from theatres of operation frequently lose a high proportion of their experienced personnel, to be replaced by these new men. Although the readiness requirements for the ship may remain roughly uniform, the personnel resources to meet them do not. In a recent example, a CVA about to be deployed to WESTPAC had only one ET-2 aboard. This individual was required to act as the lead for the remaining thirty or so technicians, all of whom were ET-3's or ETSN's. When the carrier returns, a fairly large proportion of these men, who by now will be relatively experienced, will be lost to shore schools, re-assignment, or completion of enlistment.

3. Wide Variation in Individual Proficiency

At any one time, a ship commander is apt to find himself with a heterogeneous mixture of experienced and inexperienced, trained and untrained, career and non-career personnel. This comes about through "normal" personnel attrition. This cross-sectional variation reduces the overall average proficiency. It results in heterogeneous teams whose efficiency is limited by the least experienced members. It presents problems for shipboard training, since many different levels of training are required. It places an extra burden on the more experienced personnel for training and supervision of the green men.

4. Haphazard Shipboard Training

Although individuals accumulate experience in the operational environment, it is doubtful if that experience, haphazard as it often is, represents the most effective way to bring skills up to satisfactory levels. Effective learning situations require careful pre-arrangement and are characterized by features, such as reinforcement, which may be quite rare in operational situations. Many combatant vessels, particularly the smaller ones, lack adequate facilities for conducting formal shipboard training. Personnel are already very busy with other duties, and may not be adequately trained to serve as instructors. Classroom spaces are hard to find. Audio-visual aids, text books, and the other requirements for efficient training may be lacking. For these reasons, for many of the personnel manning a ship, important aspects of their training stop at the water's edge.

5. Unwieldly Team Training Exercises

Training situations which are designed to exercise groups of men, from small teams aboard a single ship to task group and task force size, become progressively more unwieldly and expensive as the size of the group increases. The large fleet exercises at sea, which are recognized as indispensable dress rehersals, are extremely difficult to implement to ensure that worthwhile benefits are obtained. There are unsolved problems of scoring, evaluating, and diagnosing personnel actions. Consequently, accurate information is unavailable about changes, if any, in personnel performance. The complexities of the plans, the organization, and the scheduling involved in these large exercises, and the expense involved in running them off, makes it especially important that the maximum amount of training results from them.

6. Uncoordinated Operations and Personnel Subsystems

The operational commitments of a ship, or of the force to which it belongs, oftentimes are at variance with the methods and objectives of personnel readiness. It may not be possible for a ship commander to spare key personnel for shorebased schools. He may not be able to give the most poorly trained members of his crew opportunities to learn in those situations in which their eerors might have serious consequences for the safety of or for the evaluation of the ship as a whole.

In his position at the end of the "personnel pipline", the ship commander is, in one sense, required to take what comes out of the pipeline. He is in a position of having to do the best he can with what is given to him. Under these circumstances, it is not surprising that personnel readiness is the major limiting factor in ship and force readiness.

7. Technically Sophisticated Weapon Systems

It is common knowledge that weapon systems in the fleet today are, by all criteria, more sophisticated than those which were in use at the end of World War II. Technological advances in all the areas which support and produce the systems are well known. There is no need to belabor the point; this has imposed greater demand for technical training of the personnel who are expected to operate and to maintain these systems.

II. THE CONCEPT OF A PERSONNEL SUPPORT SHIP

The concept that is proposed here is that of a personnel support ship analogous in some respects, but only in some respects, to hardware tenders. The personnel support ship would perform its most important functions in ways that are not characteristic of an ordinary tender.

1. Seagoing Support

A variety of training functions, extending from the individual to the fleet level, would be performed by the personnel support ship while it accompanied other ships at sea. This would not necessarily be confined to large units on tactical missions. It is recognized that the tactical utilization of combatant vessels has changed drastically in recent years. The old tight formation, protected by a bent-line or a circular screen while steaming majestically over the horizon, no doubt is a thing of the past. Tactical units may be smaller and there may be a larger variety of them today. Ships may spend a considerable portion of their time in transit either in very small groups or as single ships. Yet there are situations in which, even in transit, a number of ships are found in reasonable proximity to each other. An example is the current practice of rotating groups of ships between WESTPAC and the Pacific Coast. Under the varied circumstances in which the opportunity for providing training support while at sea presents itself, the personnel support ship would perform important training functions for the other forces. Under the same circumstances, it also would perform other functions. Important ones of these are concerned with corrective and preventive maintenance of electronic equipment.

2. In-Port Tender

When in port, the personnel support ship would most resemble the ordinary tender in its functions. It would be a floating base for many of the needs and activities associated with the personnel subsystem. It would continue to provide training services of a number of different types. It also would provide many of the more routine record-keeping, assignment, and scheduling services necessary for the personnel organization. In this respect it would take over a large proportion of the "paperwork" that now deluges all combatant vessels. A key factor here would be the high-speed, digital, data-processing facilities which would be aboard the support ship.

3. Configuration of the Ship

The facilities and functions, which will be described in some detail below, might be housed in a number of different sizes of hulls. This is a question that would require a more prolonged consideration of the factors, such as the probable sizes of the forces that would receive seagoing support. Obviously, the smaller the hull, the less expensive the ship, but the fewer the functions and facilities that can be housed aboard. For the purposes of describing the basic concept here, it will be assumed that a relatively large ship, for example, a CVS, would be modified to serve as the personnel support ship. It may be that further study of the concept would suggest that, rather than one large ship, a number of smaller ships would be more suitable. However, judgment on this question is reserved at this time.

III. IMPROVEMENTS IN PERSONNEL READINESS OFFERED BY THE CONCEPT

1. Objective Criterion Information

Quantitative, objective, criterion information is fundamental to more effective training and utilization of personnel. It is the basic information upon which many operations designed to improve personnel readiness depend. Yet this information is not readily available either for the performance requirements or for the performance capabilities of fleet personnel. An important function of the support ship would be to provide for the collection of this criterion information. This would be done by analysis of performance requirements and application of suitable proficiency tests. The assessment of the performance capabilities of fleet personnel would depend upon the application of sophisticated performance and achievement tests constructed and administered according to the best established psychometric principles.

The administration of these tests might be handled in a number of different ways. Two possibilities that seem attractive are as follows. One would be to temporarily transfer those individuals to be tested to the support ship, without advanced notice. There, their capabilities would be assessed by subjecting them to job-sample and other kinds of tests. Representative sampling from the fleet could thus provide the kind of detailed information that would be of utmost value to those people concerned with improving personnel readiness.

Another way to approach this assessment has been characterized as "jury duty." In this case, the individuals to be tested would be notified that, at some specified future date, they were to be tested extensively regarding their capability to perform the tasks that were associated with their duties. This warning period would allow them an opportunity to brush-up on the areas in which they felt weak. This would be a desirable consequence of such a procedure.

The acquisition of criterion information would be extended to teams. Data about team performance would be collected during training exercises as well as in special testing situations. All this criterion information would be recorded and made available in a form that would be useful to training , to command, and to others concerned with improving personnel readiness.

2. Feedback to Shorebased Training

One of the chronic problems which besets shorebased training today is the disconnect between these facilities and the environment in which the training is expected to pay off. Shorebased schools are both geographically and philosophically remote from this environment. Although some informal feedback reaches them from the fleet, in the form of periodic conferences, and of individuals rotated to training commands from fleet duty, these sources cannot be expected to provide detailed, objective criterion information. This problem would be solved by having this information collected in the performance environment by individuals with this responsibility. This would provide shorebased training facilities the information necessary to adjust their curricula and training intervals to the job requirements in the fleet.

3. Effective Shipboard Training

The personnel support ship would provide the means and the specialized personnel for ensuring that shipboard training is conducted systematically, that it is planned to correct observed deficiencies in personnel readiness, and that it presents worthwhile learning situations to the participants. It should represent an extension of the shorebased training. It is recognized this is not now capable of providing the necessary maintenance of high skill levels, or, in some cases, of developing skills to a high enough level.

The personnel support ship would have classroom and training laboratory facilities aboard, and would have a group of training specialists whose reponsibilities were solely for shipboard training. It would provide the major items, then, that are missing in the fleet today; personnel and facilities. The training functions that the support ship would perform will be described in detail later. In general, they will be concerned with extending the training begun by shorebased establishments, tailoring it to specific needs, and fitting it into the operations environment. These training functions will be the most important services provided by the support ship.

4. Integration of Shipboard and Shorebased Training

Enough is known about human learning, forgetting, and interference from intervening experience to lead to an extension of current concepts of training. High skill levels, particularly in technical areas, deteriorate rapidly without reinforced practice. Although shorebased schools may be able to develop skills to reasonably high levels, loss of these skills can be very rapid after the technician graduates. The haphazard reinforcement that he may receive while performing his job does not ensure that he continues to develop a well-rounded repertoire of skills.

The personnel support ship offers a means for integrating shipboard and shorebased training in terms of these and similar considerations. The effects of shorebased training need not be lost due to the lack of opportunity to maintain skills and to consolidate learning.

5. Team Training Exercise Simulation, Control, Analysis, and Development

The functions performed by the personnel support ship for individual training would be extended to team training. However, the team training problem is more complicated. Team training exercises are more difficult to plan, to conduct, and to analyze. It is much more difficult to ensure that these exercises represent profitable learning experiences for the participants. The requirements for team performance are less clearly known. Team performance is more difficult to score.

All of these differences betwen individual and team training make it more difficult to bring the latter off successfully. Its greater requirements for facilities and specialitsts would be met by the personnel support ship. The ship would be an "exercise ship" at sea, controlling the exercise, simulating information system inputs, preserving a history of the actions of the units involved, and providing post-exercise debriefing.

The support ship would be the center for planning and developing new exercises. It would be the instrumentality for improving upon the current exercises by including such factors as tactical surprise and counteraction by the simulated enemy.

6. Efficient Utilization of Limited Technical Personnel.

A realistic appraisal of the manpower picture in the Navy leads to the conclusion, however unpleasant it may be, that there always is going to be a shortage of highly skilled technical personnel. It is important that these personnel be utilized as efficiently as possible. The personnel support ship offers a new approach to this utilization problem.

Electronics maintenance is an example of how this might work. Since there are not enough of the most experienced and most highly skilled technicians to meet each ship's needs, a nucleus of these would be concentrated aboard the support ship to provide what will be called corrective maintenance backup. These experts would serve as consultants for the technicians aboard other ships, communicating with them via the communications facilities. A technician faced with a trouble shooting problem in an equipment which he could not solve, would be required, after passage of a specified time interval, to "call up" the expert on the support ship and seek his assistance.

This would be "on-line" backup, in distinction to the type of maintenance support now furnished by tenders. The objective would be to reduce the excessively long down-times that result from extremely difficult trouble shooting problems. This type of corrective maintenance backup is common in industry. It has been used for many years with digital computing centers. It works. This utilization of the best technician talent would be in sharp contrast to the occasional waste of this talent that can be observed in the fleet today. Similar utilization of talents in other technical areas should be possible.

7. Integration of Fleet Personnel and Operations Subsystems

The coordination problems alluded above, with respect to these two subsystems, could be alleviated by the personnel support ship. Personnel information would be quickly available to fleet, force, group, unit, and ship commanders to assist them in planning and executing operations. This availability would be made possible by the presence on the support ship of a digital data-processing center with tape or disc memory for storing personnel information. Using this information as a base, and processing it with computer programs, command would be able to schedule the utilization of their personnel more effectively, and would be able to project personnel strengths for future operations and requirements. Quantitative and qualitative personnel resources would be at command's fingertips. This information could be utilized to develop optimum trade-offs among the many conflicting personnel requirements of the fleet.

8. Reduction of shipboard Paperwork

The data-processing center on the support ship would be used to replace much of the paper-shuffling that has become such a load on ship commanders and other responsible personnel. This function of the support ship would be analogous to some of the functions routinely performed in the business world by data-processing centers. It should be feasible to reduce the paperwork load to a minimum. This would free valuable personnel for more important duties. The lags and inefficiencies in the paperwork system would be reduced. The morale of personnel would be improved.

9. Improvement of Shipboard Morale

The support ship would perform a number of functions and have several facilities which should directly contribute to an improvement of morale.

Personnel would be utilized more efficiently. Training would be tailored to individual needs. Inexperienced technicians would have support from experts. The many minor "disconnects" in the system would be reduced. And, the support ship would include personal services and personal counseling. All these factors should have a beneficial effect on morale.

The more obvious factors here would be the personal services that would be available aboard the support ship. It would serve as a center for counseling individuals, for performing the functions of the Chaplain's office, and for providing special services. The last could be extended considerably by utilizing some of the facilities that would be aboard the ship.

Although entertainment and recreation are undoubtedly important factors in morale, it is assumed that the more basic factors relate to the individual's ability to identify with the group and the organization. The contribution the support ship would make to improving the efficiency of the organization and to more enlightened personnel management would be expected to improve these basic factors.

10. Increased Readiness Per Dollar Cost

The support ship would represent a major investment. It would need much more intensive study, requiring much more time than now is available, to identify and quantify the trade-off between this cost and the improvement in personnel readiness that would result. However, it is believed that the improvements in personnel readiness that are offered by this concept would represent a gain of a magnitude that would be worth far more than the investment required.

Some of these improvements can be re-emphasized here. The proficiency levels of teams and individuals would be upgraded. Scarce technical talent would be spread more efficiently to the areas in which it is needed and not wasted in other areas. Operating personnel would be relieved of a burdensome load of paperwork and would be able to devote more time to the more important aspects of their jobs. Training would produce better results per dollar cost. Costly errors in maintaining and operating expensive weapon systems would be reduced. Improvements in shipboard morale would be reflected in rising re-enlistment rates. The data base would be established for continually refining and developing training methods for individuals and teams. The improved personnel readiness would contribute materially to the readiness of the forces to perform their missions and tasks.

IV. FUNCTIONS OF THE PERSONNEL SUPPORT SHIP

1. Individual Readiness

a. Assessment of capabilities. Detailed, objective criterion information describing both the performance requirements for, and the performance capabilities of fleet personnel would be collected by the psychometric specialists aboard the personnel support ship. The principal instruments for assessing individual capabilities would be standarized performance and achievement tests constructed and administered according to the best principles.

It was pointed out in the introduction that the actual administration of criterion measures could be done in several ways. If it were scheduled for regular intervals and if the individuals to be tested were notified in advance, it undoubtedly would serve as a stimulus for these personnel to review the requirements for their jobs. This would be a beneficial side effect, but of course it might not reflect the true capabilities of the personnel. Another procedure would be to select subjects at random, without prior notification. The results of this procedure might be a more accurate reflection of the actual capabilities of the personnel.

Identification and description of performance requirements would require the development of suitable methods. The final objective would be a quantitative and general task taxonomy through which specific job requirements could be related to more general aptitudes and abilities.

The proficiency testing would be done at regular intervals and the results would be recorded as a part of each individual's record. These records then would be used to describe the levels of proficiency available at any one time aboard any one ship, and as the basis for scheduling shipboard training for the individual.

The psychometric section would be responsible for developing and refining better methods of assessment. To this end, task analyses and proficiency test scores would not be filed away somewhere and forgotten. This criterion information would be analyzed for indications of how better criterion measures could be developed. Ultimately, the psychometric section aboard the support ship would be expected to bring quantitative rigor into this important field, in cooperation with the shorebased facilities.

The presence of a data-processing center aboard the support ship would add materially to the resources of the psychometric section. With suitable programs, analyses of test scores and task data could be done very quickly. The records for individuals could be stored on magnetic tape. The technology for doing this exists. Tape files of this sort are routinely used by insurance and banking firms.

b. Remedial training. Our standard methods of training individuals in groups called classes do not result in a uniform level of skills and knowledges in the graduates. The variation that would be normally expected in a class sometimes is increased in Navy schools where shortages exist of the technicians being trained. Under those circumstances, individuals at the lower end of the class may be carried through the training in hopes that they will prove to be useful anyway. Not all of the men aboard a ship may have the opportunity to go to the class A or C schools which would prepare them for their duties.

These sources of variance in individual proficiency would be attacked by the training specialists aboard the support ship. Using the criterion measure records, they would schedule remedial training for groups of individuals who exhibited common deficiences. Early identification of such groups would be done by means of sorting the records on the tape files in the computer center.

This remedial training would utilize programmed instruction as well as the more conventional techniques. However, whatever techniques might be involved, the objective of remedial training would be to reduce individual deficiencies by tailoring training courses to correct these deficiencies.

c. Refresher training. It was pointed out in the introduction that high skill levels, particularly in technical areas, tend to deteriorate rapidly without practice and reinforcement. Ordinarily, the job environment does not provide this in a sufficiently broad or systematic fashion. Sometimes, skilled technicians are assigned to non-technical duties for substantial periods of time, during which a large proportion of their skills might be lost. Then, when they are reassigned to a technical job, they may be in need of refresher training to bring them back up to the desired levels.

Learning, forgetting, and interference from intervening experience are closely interwoven. It is in this regard that the support ship's training facilities would provide the continuity that is desirable after shorebased training ceases.

As in the case of remedial training, the refresher training would be tailored to suit individual needs. Scheduling and planning it would depend upon the criterion information in each individual's record, and upon interaction with shorebased training staffs.

d. Modernization training. This would fulfill the requirements imposed by modifications of equipment; or introduction of new equipment, new tactics, and new techniques. All of these require that new knowledges and skills be learned by personnel.

The support ship would play an important role in those instances in which the changes might not have the desired effects unless implemented through the indoctrination and training of the personnel. There have been numerous such changes in the past which might have been more effective had they been supported by this kind of field implementation. Modernization training would be concerned with insuring that desired changes actually are implemented.

In some cases, this training would provide continuity beyond the service testing of weapon systems. It would utilize the findings of service testing to develop training courses and curricula.

In short, whenever changes in hardware, organization, or procedures would require a period of adjustment of fleet personnel skills, knowledges, and attitudes, the modernization training function of the personnel support ship would be important.

e. Experimental training. It is well known that training research has uncovered promising techniques which have not been picked up and utilized in the day-to-day training establishments of the Navy. It is well known, too, that promising results in a laboratory setting may not generalize perfectly to the much less sheltered setting of seagoing operations. Research results could be tested in the harsher environment by the support ship.

The ship would provide the facilities and personnel for extending promising experimental results to this environment and validating them. It would act as the intermediary between the fleet and training researchers when the latter required access to the fleet. The training personnel aboard the ship would serve as the advisors and guides to personnel of the Type and Fleet commanders desirous of investigating experimental training techniques of their own. These services would include assistance in planning designs, in drawing samples, in scheduling subjects, and in carrying out the procedures of the date of collection and analysis.

f. Scheduling and records. It has been indicated that personnel records would be kept on tape files. These would be a part of the digital computer center aboard the support ship. With this type of fast-access, large-capacity storage, more detailed information about each man can be recorded. This detailed information would be the basis for training, manning, assignment, and scheduling decisions. Using these records, it would be possible for commanders to obtain up-to-date information about strengths and weaknesses in their personnel structure. They could project trends into the future, determine immediate personnel readiness, schedule and assign talent more effectively, and, generally exert more satisfactory control over the personnel subsystem in the fleet. This function of the support ship might be considered to be a seaward extension of concepts which may grow out of the MOON and CAPRI projects.

2. Team Readiness

a. Scoring, evaluating, and diagnosing team capabilities. The problem of obtaining adequate criterion measures extend to team performance. The problem is a much more difficult one here, but the need is no less great. In this sphere, even more than in individual training, team training has been forced to flounder on, doing the best that it can without these adequate criterion measures. It would appear that this is due primarily to the expense of getting such measures. This expense is compounded of the cost of observing team performance, recording team member responses, working out the relationships between individuals and team performance, and assembling teams in an environment in which representative performance can be elicited.

A function of the support ship would be to collect this information from the teams while they are being exercised at sea. The digital computer center aboard the support ship would provide the facilities for recording their performances and for analyzing them. This function would be performed primarily for the NTDS ships, but it also would be extended to non-NTDS ships.

The philosophy here, as in the case of individual performance testing, would be to develop substantial records of team performance which could serve as normative and diagnostic data. Ten years of experience in performing a similar function for the SAGE system in the Air Force has resulted in techniques and in knowledge that could serve as a point of departure for implementing this function with the support ship. The digital equipment and the computer programming group associated with it would play a key role in this implementation.

b. Planning and developing team training exercises. The support ship would perform the function of planning exercises for training teams, from ship teams to task forces, basing the planning on the performance records of the particular teams involved. The intent here would be to extend this type of training from the shorebased facility to the operational environment and to make it more effective in that environment. Personnel aboard the support ship would have responsibilities for this planning and scheduling, from the identification of specific needs to the production of Op Orders and the pre-exercise briefing of the teams.

The support ship's specialists would be responsible for developing better team training exercises. They would utilize the histories recorded from the exercises, and from analysis of these and from observation of the requirements of the situation would develop more effective exercises. The fact that the support ship would be present as an exercise control ship while fleet exercises are being conducted would help in this development. Exercises would be tailored to the training needs of the particular teams involved. Also, simulation capabilities made possible by the computer center would be utilized to create more dynamic training situations. In these situations, interaction between the actual and the simulated forces could be more extensive and more realistic. Thus, the elements of surprise, counteraction, and changes in force structure during an exercise could be incorporated in the training.

c. Controlling and monitoring exercises. The support ship would act as force exercise ship in a fashion somewhat analogous organizationally to a force air control ship. It would schedule, initiate and control the conduct of fleet exercises, and monitor the performance of the teams involved while the exercises were in progress.

An important aspect of this function of the support ship would be its capability to exercise the smaller teams, such as the CIC team or a portion of it, while other ships were underway but no necessarily engaged in formal fleet exercises. Time in transit might be utilized in this way.

d. Briefing and debriefing teams. Studies of group learning in task-oriented teams indicate that the value of feedback about performance depends very heavily upon its timeliness. The support ship would have the facitlities for analyzing performance histories, using computer programs, and for producing debriefing information as soon as the exercise is over. In fact, in those cases in which NTDS ships were involved, some feedback regarding the adequacy of performance probably could be supplied during an exercise.

The support ship would be capable of supplying this information to other ships and it also would have facilities aboard for this purpose. The debriefing rooms would have the necessary displays, in some cases on-line with the computer, to present detailed and accurate debriefing information. These sessions would be conducted by the training specialist aboard the ship.

The necessary briefing for preparing teams for exercises also would be conducted in this fashion. This would be analogous to the "pre-sail" briefings that often are given at a FAAWTC ashore.

These briefing and debriefing sessions would be conducted as learning sessions, designed to be optimum learning experiences for the participants. For this reason, most of them would be conducted aboard the support ship, to permit the all-important face-to-face interactions between the training specialists and the participants in the exercises.

3. Electronics Readiness

a. Corrective maintenance in depth. The support ship would make it feasible to organize electronics maintenance to more efficiently utilize scarce technician talents. Corrective maintenance in depth consists of placing highly skilled and experienced technicians aboard the support ship and utilizing them essentially as inter-ship technicians. They would be on call from other ships in the force and would be available when the technicians aboard the other ships ran into difficulties in trouble shooting equipment. The concept would be implemented in much the same fashion as similar procedures in industry.

Technicians aboard the other ships would be given a certain amount of time to trouble shoot particular equipment. This time limit would be determined by the system availability requirements of the operations departments. It might be quite liberal for some equipments for which the availability is not critical. The time limit might be quite stringent for other types of equipments upon which the operational readiness of the ship almost always depends. In either case, the technicians aboard the ship would be allowed to attempt to trouble shoot the equipment up to the specified time limit. Then, they would be required to call up the support ship specialist and ask for help. The specialist on the support ship would have all of the necessary technical information at hand, and would be able to provide assistance in most cases via standard communications links. In some cases, they might have to use the slow-scan television broadcasting facilities which are proposed as major items aboard the support ship. These items will be described in detail later. It is sufficient here to point out that, with such facilities and with the relatively simple monitoring equipment aboard other ships, the electronics specialists would be able to give technicians visual aid.

It is important to emphasize that this concept of corrective maintenance in depth is one of "on-line" assistance. It would be given to the technicians at the time that they needed it, within the active repair time, and would be designed to reduce these active repair times, resulting in acceptable MTTR's. It has been found in the commercial system that a further beneficial effect accrues. The technicians who are trouble shooting know that they are going to have to call for help within a certain period of time. As a matter of pride, they work harder and faster to get the job done themselves. When the technician did call for assistance, he would be receiving expert guidance in the situation and at the time in which it would do him most good as a learning experience. The immediacy of reinforcement he would receive would make his learning much more effective. He could be given step-by-step guidance. This tutorial assistance is recognized as highly valuable for training.

b. Preventive maintenance scheduling. The chaotic state of preventive maintenance in the fleet today can be attributed, to a large extent, to the great difficulties attendant to fitting preventive maintenance requirements to the limitations in the number of personnel available for performing this maintenance. Much preventive maintenance that in theory is required for equipment, simply is not done. Routines that are prescribed for a particular equipment are unable to take into account the fact that this equipment is just one of many aboard a ship, and that the number of technicians that any one ship can carry is limited.

Preventive maintenance schedules presumably are based upon accurate data about failure rates and wear rates. But in the fleet context, it also is necessary to recognize that there simply may not be enough people to get all of the specified routines done. Therefore, critical items with critical requirements for preventive maintenance should be arranged in some priority order.

This is a very complex scheduling problem. It is not feasible without the aid of a high speed digital computer. There are just too many factors to take into consideration. There are just too many equipments with preventive maintenance requirements.

Again, the precedent has been established in industry. Preventive maintenance scheduling has been "automated". An example is the MI/DAC system developed by the Mobil Oil Company. This system automatically schedules preventive maintenance for equipment, issues assignments to technicians, records updated information on assignment completions, reports delinquent assignments to management, and makes realistic performance comparisons for cost analysis.

This is the type of control over preventive maintenance in the fleet that probably is essential if it is to be performed. The concept is in line with earlier concepts which were described in EPRG reports and in the Satterwhite plan several years ago. The computer facilities for implementing those concepts were not available. These facilities are now available and this type of computer application is a routine matter.

Preventive maintenance scheduling ultimately should be based upon more accurate information about requirements. This information would be gathered by the support ship in the form of maintenance records, and would be utilized to establish the more realistic intervals and requirements which might be much less demanding on personnel.

c. Maintenance records. It is well known that malfunction reporting systems are extremely difficult to implement. They generally go awry at the input end. Since these systems represent just so much more paperwork for the men in the field, it is difficult to get them to fill out the forms. This experience with malfunction reporting systems is universal. The services have had the problem for many years. Severe biases are undoubtedly introduced into the system by the selective actions of the technicians.

The support ship would be an ideal medium for implementing a more effective malfunction reporting system and for collecting the associated maintenance information that could be so valuable in reliability and maintainability. The ship would serve as a center for collecting and recording this information. The specialists aboard would devise and implement statistical sampling plans. (It might not be the most efficient way to proceed to attempt to collect all malfunctions, and all malfunction data for all of the equipment in the Navy. There is a precedent in operations research for using a sampling plan.) The support ship personnel would be responsible for the bulk of collection and recording. The technician at the site would relay the information to the support ship via communications, where it could be punched on cards or put on tape. This would eliminate the burdensome paperwork now required of the technicians. Furthermore, with the support ship in the same environment, the technicians could be educated and supervised to eliminate the biases that they normally introduce.

An important aspect of this function would be the capability, in the computer center, for data reduction and data analysis. Results then could be printed out for local commanders to use, or sent to shorebased centers where further reduction and analysis might be performed.

d. Inventory control. The support ship would have facilities for stocking critical equipment items. These items would be determined from the maintenance records, although the determination might not depend altogether upon failure rates. For example, there are rarely failing items which nevertheless cripple an equipment when they do fail and for which spares seem ordinarily to be very difficult to get. The support ship might in these instances fulfill a supplementary role for the standard supply facilities.

The chief advantage of this function would be the close-up control of inventory offered by the support ship, since it also would have the responsibility for keeping failure records. It could serve as an important control point in the logistics pipeline.

e. Transmitter and receiver test and calibration signals. As electronic systems become more sophisticated, there are greater requirements for maintaining accurate frequency standards, accurate timing standards, and accurate measurement of transmitter outputs and receiver sensitivities. The support ship would have facilities aboard for performing these functions. These would be designed to add materially to the capability for determining the performance levels of electronic sensors and of communication systems. The facilities would include monitoring equipment for the outpots of electronic equipment on the other ships and for assisting in its correct operation in this respect.

4. Medical Readiness

a. Emergency treatment. It would be possible to provide certain scarce and sometimes bulky facilities, such as iron lungs, aboard the support ship. Prompt availability of these items could mean the difference between life or death of the patient. These facilities would include an emergency operating clinic as well, and other items that would be required to deal with medical emergencies. They would be staffed with the medical talents commensurate with the requirements.

b. Environmental monitoring. There are a number of environmental hazards which the support ship could monitor with the proper facilities and staff. Radiation hazards are known to exist in a high degree aboard some of the combatant vessels, such as carriers, which carry a large amount of varied electronic equipment. Radiation hazards from atomic sources also should be monitored by the support ship. Other hazards would include bacteriological and chemical warfare, ambient noise and temperature, and dangerous fluids and gases. The support ship could carry the specialist and the specialized equipment for doing this environmental monitoring. This would be an analogous to an industrial medicine program.

5. Personal and Special Services

a. Personal Counseling. An important factor in improving the morale of personnel would be the availability of counseling services covering personal problems ranging from legal to emotional. Some of these services are performed by the Chaplain's office, and the Chaplain's office would be included in these facilities on the support ship. Extensions of the counseling services now available would be possible. For example, the possibility of dealing with minor civilian legal problems which may arise "back home" while an individual is at sea, would improve morale.

b. Special Services. The support ship would be the control point for the various types of entertainment that are made available to other ships. This distribution of movies, of reading material, and of similar items would be made through this ship. The ship might also carry facilities for a gymnasium and for other sports. The television broadcasting facilities aboard could be used as an entertainment medium.

c. Pay, accounting, and banking. The support ship would perform these personnel functions. It is likely that the bulk of this could be automated by means of the digital computer facility aboard.

V. FACILITIES ABOARD THE PERSONNEL SUPPORT SHIP

A number of major facilites would be required to assist in the performance of the functions described above. While none of these is considered to require an entirely new hull, they would require that an existing hull be extensively modified.

1. Tactical and Functional Simulators

The support ship would carry problem generators and the other equipment necessary for tactical and functional simulation. The digital computer center would be used in an on-line capacity for this purpose. It would be compatible with the major systems coming into the fleet, such as the NTDS, and could function on-line with these systems. This equipment would include the necessary special devices for recording team performance histories, for simulating enemy targets, for providing feedback to trainees, and for scheduling and controlling exercises.

The support ship would have facilities for providing training in critical tasks. For example, there is a need for decision-making trainers which could be programmed for training decision-making in a variety of operator jobs. It is not anticipated that the support ship would carry extensive mock-ups aboard. If required, it might have a general purpose mock-up, containing the basic items of equipment that are found in CIC's, and constructed so that it could be configured to major types of CIC's aboard combatant vessels.

2. Slow-Scan Television Transmitters and Receivers

Recent technical advances make it possible to broadcast television signals in a much narrower bandwidth, using standard radio communications nets. These slow-scan systems appear to be quite adequate for educational purposes. The support ship would carry broadcast facilities. Other ships to be served by it would carry receivers. These receivers are quite simple, and can be made to occupy a relatively small space. Using this one-way system, the support ship would be able to give training to individuals and small teams aboard other ships. If it appeared to be desirable, these also could be equipped with television transmitters for a two-way system. The potentialities for using a system of this sort, with receivers modified to serve as teaching machines, are obvious. The instructor on the support ship could serve both as the programmer and program, and could introduce the flexibility that at least some programmed instruction experts consider to be desirable.

With the continued development of computer-based teaching systems, the television receivers might be switched on-line with the computer and the instruction might be dispensed via this machine. The precedents for accomplishing this have been established by several research groups.

3. Electronics Test, Calibration, and Monitoring Devices

The Navy recently has stated an objective of achieving precise frequency stability and synchronization, in order to lock time together over an entire ocean. This would provide frequency and time sources of a high order of accuracy.

A chronic problem since the development of electronic sensors and communication equipment has been the measurement of receiver sensitivity and of transmitter output. It is extremely difficult, for example, to

V. FACILITIES ABOARD THE PERSONNEL SUPPORT SHIP

A number of major facilites would be required to assist in the performance of the functions described above. While none of these is considered to require an entirely new hull, they would require that an existing hull be extensively modified.

1. Tactical and Functional Simulators

The support ship would carry problem generators and the other equipment necessary for tactical and functional simulation. The digital computer center would be used in an on-line capacity for this purpose. It would be compatible with the major systems coming into the fleet, such as the NTDS, and could function on-line with these systems. This equipment would include the necessary special devices for recording team performance histories, for simulating enemy targets, for providing feedback to trainees, and for scheduling and controlling exercises.

The support ship would have facilities for providing training in critical tasks. For example, there is a need for decision-making trainers which could be programmed for training decision-making in a variety of operator jobs. It is not anticipated that the support ship would carry extensive mock-ups aboard. If required, it might have a general purpose mock-up, containing the basic items of equipment that are found in CIC's, and constructed so that it could be configured to major types of CIC's aboard combatant vessels.

2. Slow-Scan Television Transmitters and Receivers

Recent technical advances make it possible to broadcast television signals in a much narrower bandwidth, using standard radio communications nets. These slow-scan systems appear to be quite adequate for educational purposes. The support ship would carry broadcast facilities. Other ships to be served by it would carry receivers. These receivers are quite simple, and can be made to occupy a relatively small space. Using this one-way system, the support ship would be able to give training to individuals and small teams aboard other ships. If it appeared to be desirable, these also could be equipped with television transmitters for a two-way system. The potentialities for using a system of this sort, with receivers modified to serve as teaching machines, are obvious. The instructor on the support ship could serve both as the programmer and program, and could introduce the flexibility that at least some programmed instruction experts consider to be desirable.

With the continued development of computer-based teaching systems, the television receivers might be switched on-line with the computer and the instruction might be dispensed via this machine. The precedents for accomplishing this have been established by several research groups.

3. Electronics Test, Calibration, and Monitoring Devices

The Navy recently has stated an objective of achieving precise frequency stability and synchronization, in order to lock time together over an entire ocean. This would provide frequency and time sources of a high order of accuracy.

A chronic problem since the development of electronic sensors and communication equipment has been the measurement of receiver sensitivity and of transmitter output. It is extremely difficult, for example, to measure the effective range of a search radar.

The support ship would carry facilities for frequency and time calibration. It would carry devices for measuring output of other ships transmitters and for monitoring and calibrating other electronic systems. It might be possible to arrange for such equipment to interrogate the equipment of the other ships in the force on some schedule and to maintain a record of the operational status of this equipment in this way.

The great advances in developing integrated electronic circuitry reduce the space required for most electronic equipment. Therefore, simulation facilities, transmitter test, and monitoring facilities need not necessarily occupy a large volume of space, aboard the support ship. More of these functions now can be performed per unit volume of space.

4. On-Line and Off-Line Digital Computer Center

There was frequent reference to a digital computer center, in the above descriptions of the support ship's functions. This center would consist of at least one reasonably large capacity digital computer, or of several smaller machines, with associated peripheral equipment and auxiliary tape memory. The center would function both as a conventional data-processing center and as an on-line processing center. In the latter capacity it would be used for simulation for exercises. It would interact directly with NTDS equipment. As was suggested above, there would be a number of other on-line uses of the computer center. It might be used for computer-based automated instruction. It might be used for on-line electronic equipment performance-monitoring. Under some circumstances, it appears feasible to use a computer center of this sort on-line, to do automated trouble shooting. For example, if the symptom-malfunction matrix for a circuit is known, it could be stored in computer memory and utilized by technicians trouble shooting that circuit. All the technicians would have to do would be to input the symptoms to the computer and a relatively simple program could locate the malfunction. (It should be pointed out that this possibility would be difficult to implement in proportion to the size of the symptom malfunction matrix. A systems-level matrix would be relatively easy to get for most systems; a component level matrix would be extremely difficult, if not impossible, to get for a large system.)

Off-line, the computer center would be utilized for a variety of more or less routine data-processing functions, from the maintenance of personnel and electronics equipment histories, and up-dating of these files, to doing bookkeeping and accounting chores. Although many of these kinds of things are routinely done in the business world today, the implications of being able to do this on a support ship are far from routine.

This is one of the points at which there would be promise of reducing the heavy burden of paperwork that is now placed upon the operating forces. As much of this paperwork as possible should be eliminated by automating the various semi-clerical functions involved. These possibilities might indicate that several small computers would be more desirable than one very large computer. A data-processing center organized around the modular concept certainly would fit into the current developments in the computer field, and into the practices which already have been established for the NT

5. Instructional Laboratories, Classrooms, and Booths

The support ship would have spaces for conducting classes of various sorts, both for individual and for team training. The spaces should be designed on a modular concept so that classrooms of varying sizes could be made simply by changing partitions. This would permit efficient utilization of the space.

The laboratories would be designed to teach those technical skills, such as electronics trouble shooting, that seem to be in such short supply in the fleet. They would contain equipment for doing this, but the equipment would, in most cases, not consist of complete operational systems. The more difficult parts of these systems, modified to serve as trainers, might be placed in the laboratories.

Classrooms would contain all of the audio-visual equipment necessary, such as slide projectors, movie projectors, and back-projection screens.

The instructional booths would be designed for individual training. They might be in a separate space or they might be made up as needed from larger classrooms. Functional trainers, teaching machines, and similar devices would be used in these booths.

6. Technical Library, and Information Retrieval System

The support ship would carry aboard a technical library to supplement the technical material that is carried aboard combatant vessels. The object would be to provide technical information in depth, so that it would be readily available to individual needs. The physical bulk of books might require that many of them be micro-filmed and stored in this form. The information would be made available either by a circulating library arrangement, or by a question-answering facility, in which individuals could call up and ask for answers to specific questions. In the latter case, it might be desirable to have an information retrieval system operated through the computer center. This would provide for very rapid access to the needed information.

7. Biological Laboratories and Medical Clinic

These facilities would support the medical readiness functions discussed above. The biological laboratories should contain equipment for monitoring radiation, bacteriological, and chemical warfare hazards. The radiation hazards would be of two sorts, as pointed out above. Hazards generated by electronic equipment probably are the more serious since personnel must live with them from day-to-day. For example, very powerful search radars can generate extremely dangerous radiation. It is important that there be facilities for monitoring these hazards and for determining their exact extent. The laboratory also would have equipment for monitoring nuclear radiation, and the more routine industrial hazards from noxious chemicals, extreme ambient noise, etc.

The medical clinic would contain facilities alluded to in the description of emergency functions. There would be emergency operating facilities, and devices such as iron lungs. The clinic also would have resources for more routine problems. There could be an optometry shop for fitting and perhaps for grinding new lenses for eyeglasses and a dental facility for repairing dentures and bridges.

8. Critical Item Warehousing

The support ship would have certain limited storage for "critical items" as determined by inventory control procedures. It would not in this regard replace the conventional supply system. However, its closer proximity to the operating ships would make it useful as a back-up resource.