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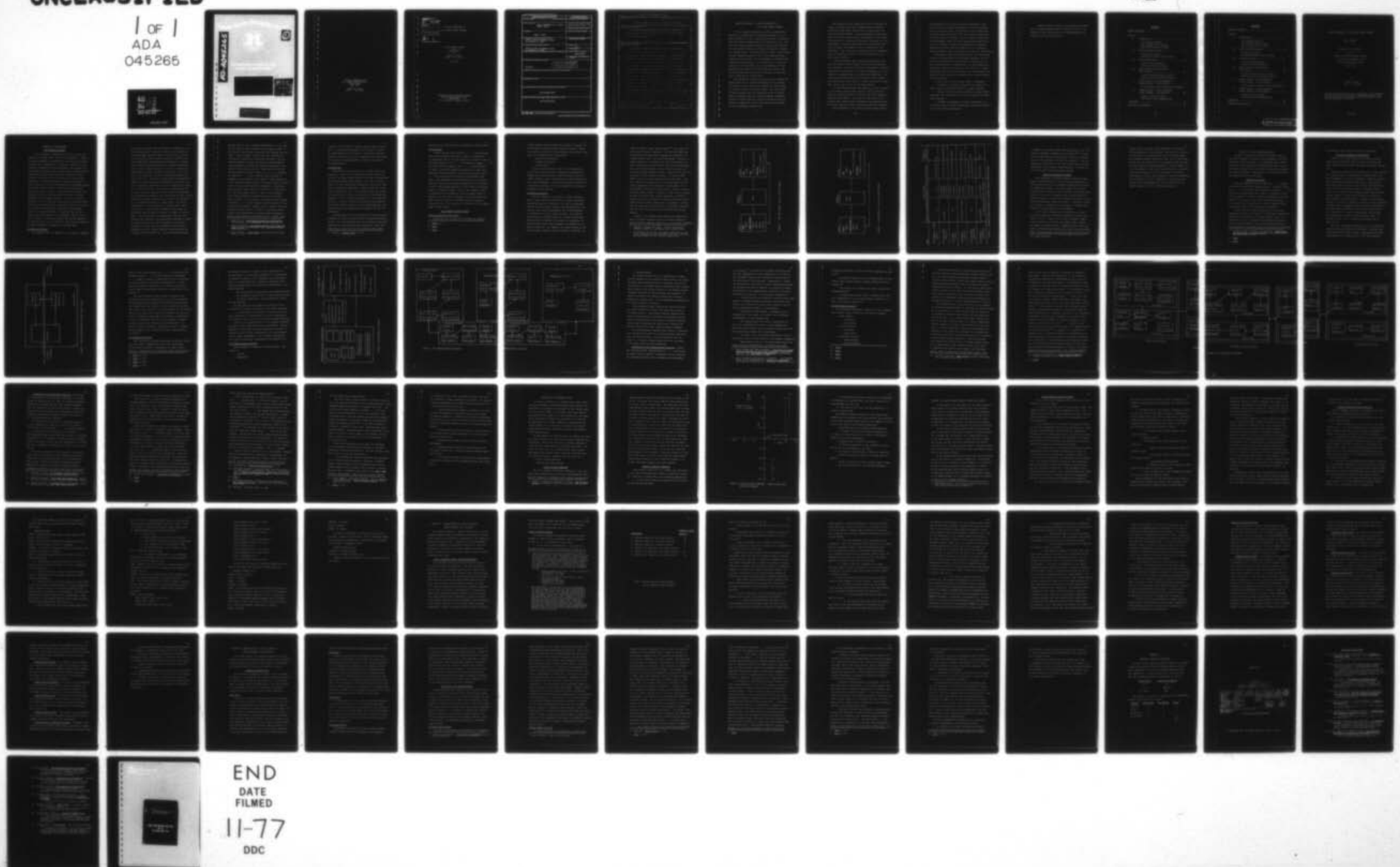

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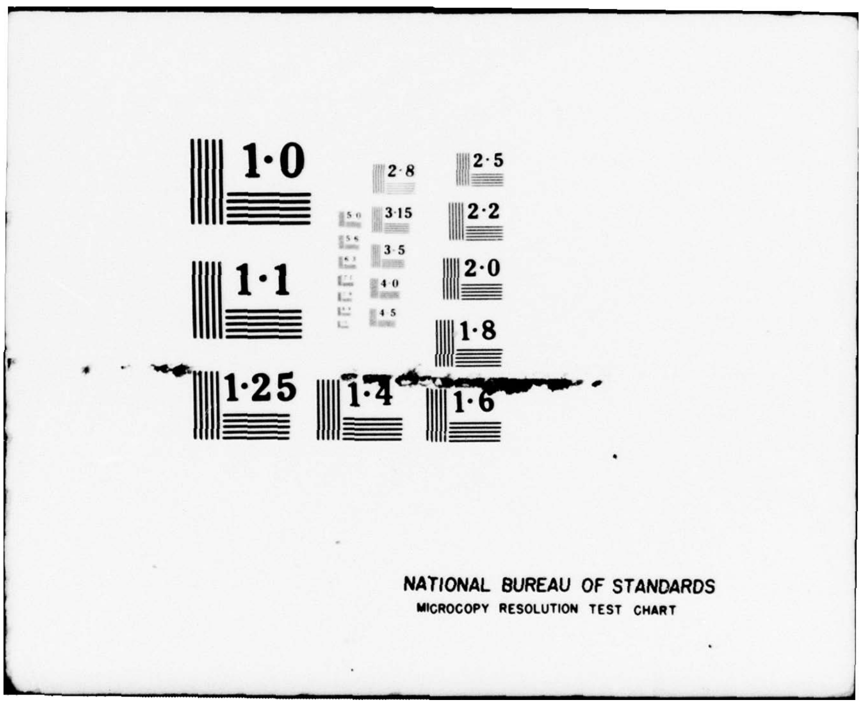
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DIGITAL COMPUTERS IN
U.S. NAVAL COMBAT SYSTEMS
STUDY REPORT
PMC 73-1

Henry E. Mielo
GS-14 U.S. Navy

DIGITAL COMPUTERS IN U.S. NAVAL COMBAT SYSTEMS

An Executive Summary
of a
Study Report
by

Henry E. Mielo
GS-14 U.S. Navy

May 1973

Defense Systems Management School
Program Management Course
Class 73-1
Fort Belvoir, Virginia 22060

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE:

DIGITAL COMPUTERS IN U.S. NAVAL COMBAT SYSTEMS

STUDY PROBLEM/QUESTION:

To identify and eliminate the causes of ineffective and inefficient use of digital computers in fleet operational combat systems.

STUDY REPORT ABSTRACT:

A distinct trend in the use of digital computers in U.S. Naval combat systems is apparent. However, the computer remains an alien member of the system, a situation described as present shock. This report is an attempt to identify and cure the causes of present shock. An automated combat system model was constructed and used as a control device against which real-world combat systems were compared. Data comparisons indicated that poor management practices were intensified as automation was increased. The actions recommended to eliminate management deficiencies included: training in perception of computers as small groups and individual members of combat systems, and the establishment of an organizational climate in which the role of computers is well differentiated and simultaneously well integrated in combat systems.

Student, Rank Service	Class	Date
Henry E. Mielo, GS-14, USN	73-1	May 1973

EXECUTIVE SUMMARY: DIGITAL COMPUTERS IN U.S. NAVAL COMBAT SYSTEMS

If I were asked to describe our life in present day America in a single word, I would say automated. It is quite difficult to try to identify items which we encounter daily that have no connection with automation at all. And yet, the digital computer remains an alien in our society not very unlike the Martian of Robert Heinlein's "Stranger in a Strange Land." In Alvin Toffler's words: "The greatest and most dangerous marvel of all is the complacent past-orientation of the race, its unwillingness to confront the reality of acceleration." In the study report I was concerned with the interfaces of men and computers as they presently exist aboard U.S. Naval combatant ships. And it was my contention that those interfaces are suffering from a condition of present shock.

The man-machine interfaces existent on U.S. Naval combatant ships are not simply predisposed to the problems of Toffler's future shock; many symptoms of future shock are already evident in advanced stages. For that reason I chose to characterize the condition as one of present shock to emphasize the fact that man-machine interfaces aboard U.S. Naval combatant ships are suffering from the disease of change now, and in some aspects, the disease is in an alarmingly advanced state.

The objective of the study report was to identify the causes of present shock and recommend possible remedies so the U.S. Navy might realize the full potential of its automated combat systems. The paper includes conceptualization of a model combat system, performance of that model when subjected to real-world situations, comparison of that performance to observed performance of actual combat systems in similar environments, and an evaluation of that comparison. The study report concluded with my recommendations for effective utility of digital computers in U.S. Naval combat systems.

A model automated combat system was constructed and used as a control device against which real-world systems were compared. The model system was predicated on idealized actions and interactions of its three subsystems; viz., the technical, communications, and behavioral subsystems. The principles and guidelines which determined those actions and interactions, when taken as a whole, described the what, when, where, why, and how of the model system.

Two different exercises were designed for use as inputs to the model automated combat system. Those tests were based on standard shipboard situations for which extensive historical data exist. The intent of those tests was to provide ideal combat system performance data against which historical real-world combat system data could be compared.

The performance of the model automated combat system when subjected to the above tests was described in terms of how the model system accomplished the goals and objectives of each test since, by intention, it was assumed that the model system operated so that the purpose of each exercise was entirely fulfilled. Actual automated combat system performance, based on surface weapon system historical data, was compared to model performance and the dominant symptoms of present shock as exhibited by the automated combat systems in fleet operational use today were identified.

Performance comparisons indicated that the three prime causes of present shock were inadequate planning, poor direction, and ineffective communications practices, an almost predictable set of deficiencies. An experienced manager would register no surprise at that result. But more significant and far less predictable was the discovery that computers either caused or intensified the observed management deficiencies.

To cure combat system present shock I recommended:

. Training in management perception of computers as small groups and individual members of combat systems.

. Bureau of Naval Personnel publish a document which highlights the participative role of the computer in today's combat systems.

. Planning requirements for combat system data to the lowest level of detail practicable, within the capabilities of the available computers.

- Senior shipboard officers should reflect and maintain an organizational climate in which the role of the computer is well differentiated and simultaneously well integrated in the combat system.

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CONTENTS

DIGITAL COMPUTERS IN U.S. NAVAL COMBAT SYSTEMS

STUDY REPORT

Presented to the Faculty
of the
Defense Systems Management School
in Partial Fulfillment of the
Program Management Course
Class 73-1

by

Henry E. Mielo
GS-14 U.S. Navy

May 1973

CHAPTER I: INTRODUCTION

THE AUTOMATED SOCIETY

If I were asked to describe our life in present day America in a single word, I would say "automated." Indeed, the daily evidences of automation in our lives have become so many and so commonplace, we have long ceased to be impressed, incredulous, or even surprised. The punched card has become the typical order form for books from book clubs, automobile license plates from state Divisions of Motor Vehicles, and proof coin sets from the U.S. Mint in San Francisco. College grade reports, monthly statements of Sears, Roebuck and Co. and Montgomery Ward installment plans, and annual mortgage and real estate tax statements are high speed printer outputs. Any American of at least elementary school age could easily add to my list of daily interfaces with automated systems. In fact, it is quite difficult to try to identify items which we encounter daily that have no connection with automation at all. As I said, we are neither impressed nor surprised by the familiar outputs of automated systems. Our society has, in the main, become accustomed to its technology. And yet I feel that the heart of automated systems, the digital computer, is still an alien in our society not very unlike the Martian of Robert Heinlein's "Stranger in a Strange Land."

Cabbages and Cyborgs

The computer (for the remainder of this paper, "computer" and "digital computer" are synonomous) is presently in its fourth generation of evolution, coming up on 30 years as an increasingly important member of our society. During that maturation process, myths, anecdotes, fictions, and most importantly, mis-impressions proliferated. Legends, jokes, and science-fiction yarns are harmless enough and can, if kept in proper perspective, serve to increase our understanding of many technological products. But in the case of the computer, they may actually have muddied the waters even more. Societal mis-impressions surrounding the computer are many and until understanding sweeps away the dust of ignorance, computers in our environment will largely be inept performers. Our society is a system made up, in part, of men and computers which interact continuously. This man-machine interface, about which much has been written, ranges from a manual ringing up of a sale on a cash register to an automatic pacing of a human heart. One easily understands the former example; a salesgirl (man) inputs sales data to a cash register (machine) which opens its cash drawer and indicates the amount of change to be withdrawn. The girl is quite distinguishable from the cash register and, therefore, the man-machine interface is clear. The situation is not so clear concerning the man with a pacemaker. In that case the pacemaker is in continual communication with a remote computer, monitoring and controlling the man's pulse rate. The line between man and machine there is not so readily identifiable. Is the machine the computer plus pacemaker or the computer only? If the latter, then the man by necessity must include the pacemaker. Many in today's society find that conclusion not necessarily erroneous but absolutely repulsive. And yet, current technical, social, and medical journals address such man-machine interfaces as emerging subsystems in our overall socio-technical system. James Martin of the IBM Systems Research Institute refers to the " . . . man-machine symbiosis . . . used to describe this new type of thinking — part machine, part human."[1] Albert Rosenfeld, in his book "The Second Genesis, The Coming Control of Life," refers to the cyborg (cybernetic organism), a cybernetically controlled human being who (which) is a strong candidate for future NASA projects.[2] And in "Future Shock," Alvin Toffler synopsizes appropriately when he states, "There appears to be no reason, in principle, why we cannot go forward . . . to build humanoid machines capable of extremely varied behavior, capable even of 'human' error and seemingly random choice — in short, to make them behaviorally indistinguishable from humans except by means of highly sophisticated or elaborate tests."[3] Indeed, there

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1. James Martin. Telecommunications and the Computer, Prentice-Hall, Inc., Englewood Cliffs, 1969, p. 20.

2. Albert Rosenfeld. The Second Genesis, The Coming Control of Life, Prentice-Hall, Inc., Englewood Cliffs, 1969, pp. 274-5.

3. Alvin Toffler. Future Shock, Bantam Books, New York, 1970, p. 211.

appears to be no reason — except, perhaps, man's reluctance to interface with machines on so intimate a basis. And again Toffler hits the mark: "The greatest and most dangerous marvel of all is the complacent past-orientation of the race, its unwillingness to confront the reality of acceleration."[4]

Key Questions

The previous section gives rise to many interesting questions. What is the "complacent past-orientation of the race" to which Toffler refers? Has such an orientation affected man-machine interfacing? If so, how? In what aspects is that orientation "dangerous"? What can be done about resolving the situation? Indeed, should the situation be resolved at all? In an abstract sense the answers to such questions fall in the provinces of philosophy and theology. But in a pragmatic sense, where those questions relate to a specific real-world application of computers, the answers should come not from the philosopher and theologian but from the technician, the manager, and the administrator.

In this paper I am not concerned with the broad philosophical or ethical considerations of man-machine hybridization. But I am concerned with the interfaces of men and computers as they presently exist aboard U.S. Naval combatant ships. And it is my firm contention that those

4. Toffler. Present Shock, p. 215.

interfaces are suffering from a condition of present shock.

Present Shock

Toffler defines future shock as " . . . the shattering stress and disorientation that we induce in individuals by subjecting them to too much change in too short a time."[5], and characterizes it as " . . . the disease of change. . . ."[6] But while Toffler recognizes that " . . . future shock is no longer a distantly potential disease, but a real sickness from which increasingly large numbers already suffer . . . "[7] the implications of futurity and potential still exist. The man-machine interfaces existent on U.S. Naval combatant ships are not simply predisposed to the problems of future shock; many symptoms of future shock are already evident in advanced stages. And for that reason I choose to characterize the condition as one of present shock to emphasize the fact that man-machine interfaces aboard U.S. Naval combatant ships are suffering from the disease of change now, and in some aspects, the disease is in an alarmingly advanced stage.

THE AUTOMATED COMBAT SYSTEM

Digital Computers in the Fleet

During the last 10 years the U.S. Navy has deployed

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5. *Ibid.*, p. 2.

6. *Ibid.*

7. *Ibid.*

several hundred digital computers intended for combat oriented missions aboard surface combatant warships. While the specific utilities of those machines vary widely, three major use categories can be identified:

- Sensor data processing
- Command and control
- Fire control

Sensor data processing refers to the processing of search radar and sonar data. Computers associated with command and control systems perform functions related to target tracking, target identification, target evaluation, and weapon assignment. Fire control computers perform the calculations necessary for target engagement by missiles, torpedoes, or gun systems.

<u>Galloping Automation</u>

For the purposes of this paper a surface combatant ship's combat system is defined as the sensor subsystems, command and control subsystems, fire control subsystems, and the men who utilize, operate, and maintain those subsystems, each acting independently and interdependently to accomplish the ship's combat mission. An automated combat system is defined simply as a combat system which utilizes digital computers; the degree of automation of any particular combat system depends on subsystem use of digital computers. For example, the combat systems of the USS LONG BEACH, CG(N)-9, and USS VIRGINIA, DLG(N)-38, are shown in Figures 1 and 2 respectively.[8,9] The starred (*) items include digital computers. The USS LONG BEACH combat system can be described as moderately automated; its primary search radar, the fixed-array SPS-33, utilizes two CP-855 computers, its command and control subsystem, the Naval Tactical Data System (NTDS), uses three CP-642A machines, one CP-642B machine, and one CP-789 computer, and its prime missile subsystem, TALOS, employs two Mk 152 Mod 3 computers for fire control purposes. At present, LONG BEACH is one of the most modern ships in the fleet. (The word "modern" when applied to a U.S. Naval system is virtually synonomous with automated or digitalized.) The USS VIRGINIA, presently in construction, exhibits a highly automated combat system. As Figure 2 shows, all its weapon systems use digital fire control computers, its NTDS is automated and the new Sensor Interface Distribution System (SIDS) which processes sensor data is automated. In each case the computer utilized will be the AN/UYK-7, presently the U.S. Navy's most powerful and versatile militarized machine.

Figure 3 is a summary chart showing the numbers and types of digital computers used in the combat systems of typical surface combatant ships; viz., one destroyer (CHARLES

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8. Charles F. Hager, CDR (USN). Private interview at CHNAVMAT (MAT-09Y), Arlington, Va., 23 March 1973.

9. For purposes of clarity, the human subsystems are not shown, although men are involved in the use, operation, and maintenance of each subsystem identified.

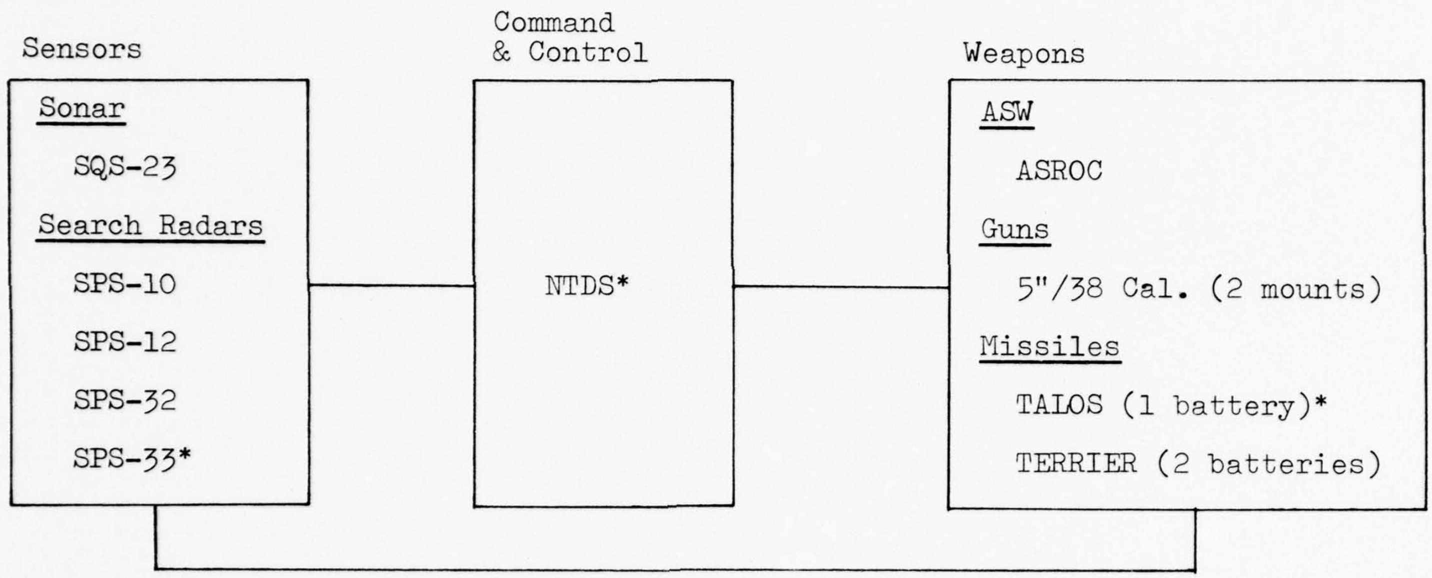

FIGURE 1: USS LONG BEACH, CG(N)-9, COMBAT SYSTEM

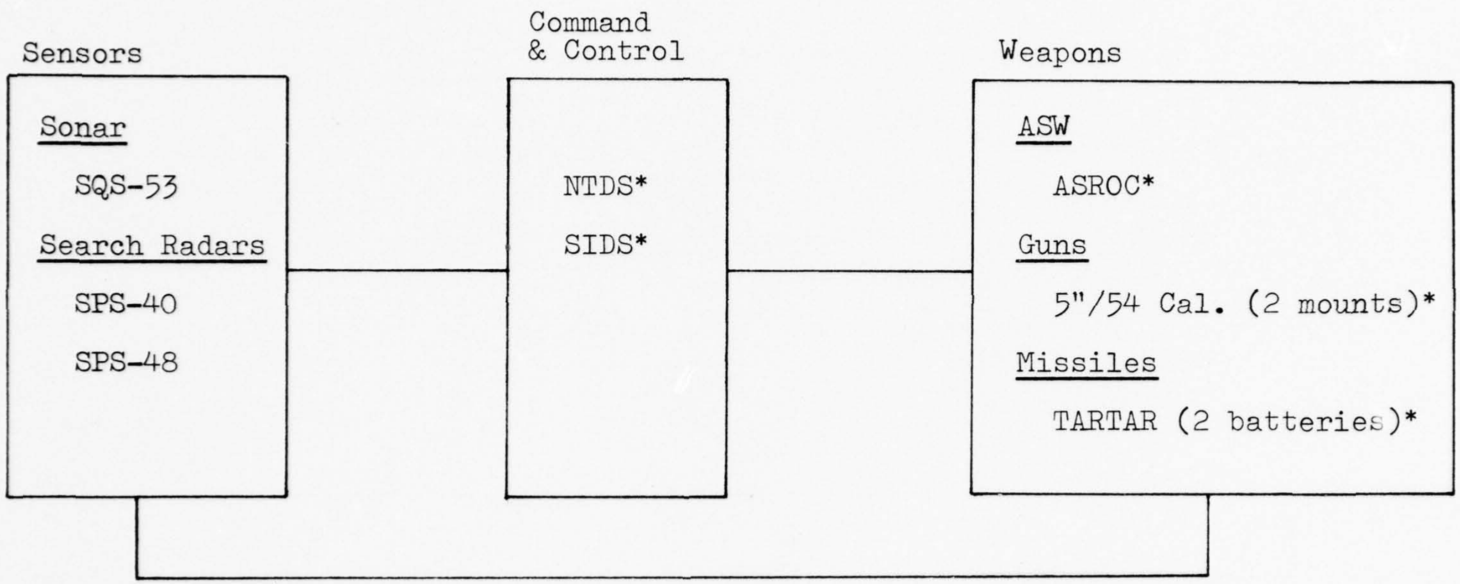

FIGURE 2: USS VIRGINIA, DLG(N)-38, COMBAT SYSTEM

SHIP	COMBAT SYSTEM SENSOR DATA PROCESSORS	COMMAND & CONTROL	FIRE CONTROL	DEGREE OF AUTOMATION
USS CHARLES F. ADAMS (DDG-2)	N.A.	N.A.	(2) Mk 152 Mod 1	Low
USS LONG BEACH (CG(N)-9)	(2) CP-855	(3) CP-642A (1) CP-642B (1) CP-789	(2) Mk 152 Mod 3	Moderate-High
USS ALBANY (CG-10)	N.A.	(3) CP-642B (1) CP-789	(2) Mk 152 Mod 0	Moderate
USS BELKNAP (DLG-26)	(1) Honeywell DDP-516	(2) CP-642A (1) CP-789	(2) Mk 152 Mod 0	Moderate
USS CALIFORNIA (DLG(N)-36)	N.A.	(3) CP-642B (2) CP-789	(4) Mk 152 Mod 0 (1) Mk 152 Mod 4	High
USS VIRGINIA (DLG(N)-38)	(1) AN/UYK-7 (1) Expanded Memory Unit (Shared)	(2) AN/UYK-7	(3) AN/UYK-7	High

FIGURE 3: AUTOMATED COMBAT SYSTEMS OF SELECTED SURFACE COMBATANT SHIPS

F. ADAMS), two cruisers (LONG BEACH and ALBANY), and three frigates (BELKNAP, CALIFORNIA, and VIRGINIA.)[10] The degrees of combat system automation are indicated in accordance with the procedure described in Appendix I. The most significant point here is the trend towards more and more automation. Both nuclear powered frigates will enter the fleet with highly automated combat systems.

SCOPE AND OBJECTIVE OF PAPER

The advantages of automated combat systems are many. Weapon system operability, reliability, maintainability, and availability have been improved significantly compared to predecessor systems. Automated command and control activities have proven far more efficient than manual techniques. Most of all, automated combat systems allow an incredible amount of real-time information and data to circulate continuously through the system. Millions of pieces of data may be transmitted in one minute. Potential capabilities and opportunities are boundless.

If the above paragraph seems inconsistent with my previous pessimistic statements concerning automated systems, it isn't. Because in the above paragraph I spoke of what might be; in reality, U.S. Naval combat systems are indeed in present shock, a condition which erodes subsystem interfaces and degrades total combat system performance. The increasing trend towards highly automated combat

10. Hager interview

systems, which I support, only intensifies the necessity for rectification of this problem. Therefore the objective of this paper is to identify the causes of present shock and recommend possible remedies so that the U.S. Navy might realize the full potential of its automated combat systems. The paper includes conceptualization of a model combat system, performance of that model when subjected to real-world situations, comparison of that performance to observed performance of actual combat systems in similar environments, and an evaluation of that comparison. The paper is concluded with my recommendations for effective utility of digital computers in U.S. Naval combat systems.

CHAPTER II: MODEL CONCEPTUALIZATION

In order to identify the causes of present shock, it was first necessary to identify those symptoms of the disease which are most serious. To accomplish this, a model automated combat system was constructed and used as a control device against which real-world systems were compared. This chapter includes a description of the process by which the model system was constructed.

INTENT OF THE MODEL

Kast and Rosenzweig define a model as " . . . a means of abstraction which aids communication."[1] And model building, " . . . one of man's most pervasive activities . . . , is the crux of conceptualization; models are developed to describe, explain, or predict pertinent phenomena in the real world."[2] The intent of the model conceptualized herein is to describe the operation of an ideal automated combat system when subjected to real-world environments.

"Models vary over many dimensions, one of the most important of which is the degree of abstractness involved."[3] The model of concern here is highly abstract since it is comprised of sets of principles and guidelines which govern its total operation. The actions and interactions of each subsystem of the model system are described by principles

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1. Fremont E. Kast and James E. Rosenzweig. Organization and Management, A Systems Approach, McGraw-Hill Book Co., New York, 1970, p. 377.

2. Ibid.

3. Ibid.

or guidelines which idealize subsystem performance.

THE MODEL AUTOMATED COMBAT SYSTEM

Figure 4 is a block diagram of the model automated combat system indicating three principal subsystems and their interactions with each other and the external environment.

Inputs are classified by originator;i.e., either friendly or non-friendly. Friendly inputs include orders from fleet commanders or flotilla commanders, logistics material and information from CONUS supply depots, enemy intelligence from support aircraft, and tactical data/information from other surface combatant ships. Unfriendly inputs refer to air, surface, and land-based target data gathered by ship sensors. Outputs are classified by recipients, again friendly and non-friendly. Friendly outputs include responses to flotilla commanders, messages to fleet commanders regarding target engagements, Casualty Reports (CASREP's), Situation Reports (SITREP's), and Casualty Correction Reports (CASCOR's) to support organizations, and tactical data/information to other surface combatant ships. Unfriendly outputs refer to missiles and rounds fired at enemy targets.

The three subsystems identified; viz., the technical, communications, and behavioral subsystems, including their actions and interactions, provide a comprehensive abstract representation of a combat system. Kast and Rosenzweig

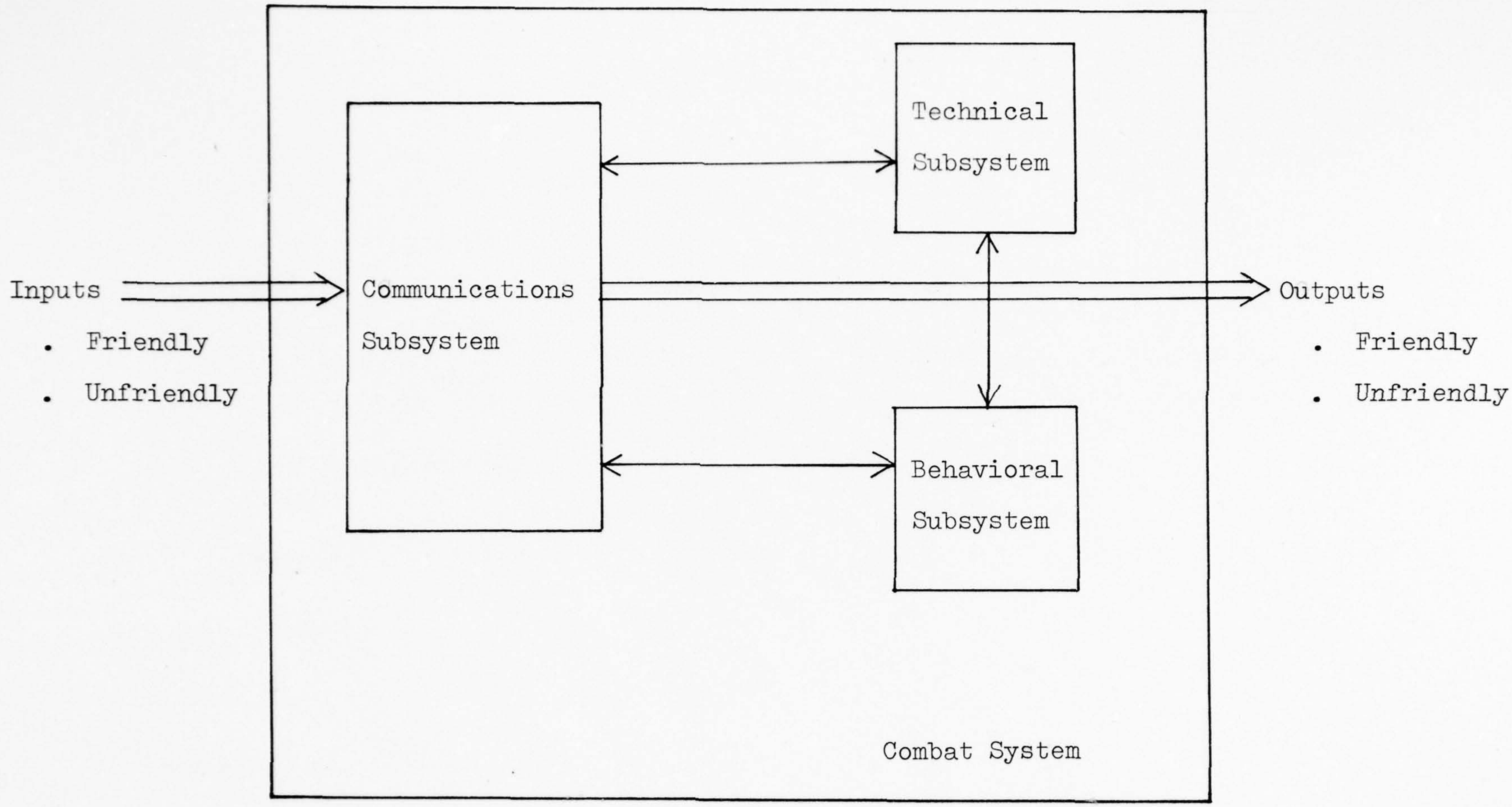


FIGURE 4: MODEL AUTOMATED COMBAT SYSTEM BLOCK DIAGRAM

refer to this representation as a " . . . structured socio-technical system . . . "[4] in which individual subsystems " . . . cannot be looked at separately but must be considered in the context of the whole organization."[5] A combat system then may be represented by a structure and integration of human and mechanical activities around various technologies.[6]

The model automated combat system is predicated on idealized actions and interactions of the three subsystems. The principles and guidelines which determine those actions and interactions, when taken as a whole, describe the what, when, where, why, and how of the model system. In the following three sections each subsystem is described and the principles or guidelines governing its operation are enumerated. It must be emphasized that this direct approach is applicable only under ideal conditions as addressed here. In dynamic, real-world systems, subsystems are sure to change and any change to one subsystem will have repercussions on the others.[7]

The Technical Subsystem

This job-oriented subsystem includes all the men, equipment and support documentation, and rules, regulations, and procedures required to accomplish the combat system mission. Activities of this subsystem range from preventive

4. Ibid., p. 120.
5. Ibid., p. 121.
6. Ibid., p. 120.
7. Ibid., p. 121.

maintenance actions to a surface target engagement by a missile system. For the model subsystem it is unnecessary to identify a specific set of equipments and crew complement; it is important only to impose the following three conditions which apply to any specific configuration of the model subsystem:

- All men involved are physically and mentally healthy,
- All equipments involved are at fully operable states,
- All rules, regulations, and procedures are effective and efficient.

The only principle governing the operation of this subsystem was a logical derivation of the above conditions:

- The performance of all jobs and tasks by the technical subsystem is in accord with its rules, regulations, and procedures and is 100% effective and optimally efficient.

Figure 5 is a representation of the technical subsystem showing its three modules and their interactions. Typical elements of each module are also identified; the lists of elements are by no means comprehensive but are representative of module membership. (For a complete description of a typical large ship's organization, see Appendix II.)

<u>The Communications Subsystem</u>

This subsystem is comprised of three modules: (See Figure 6)

- man-man
- man-machine

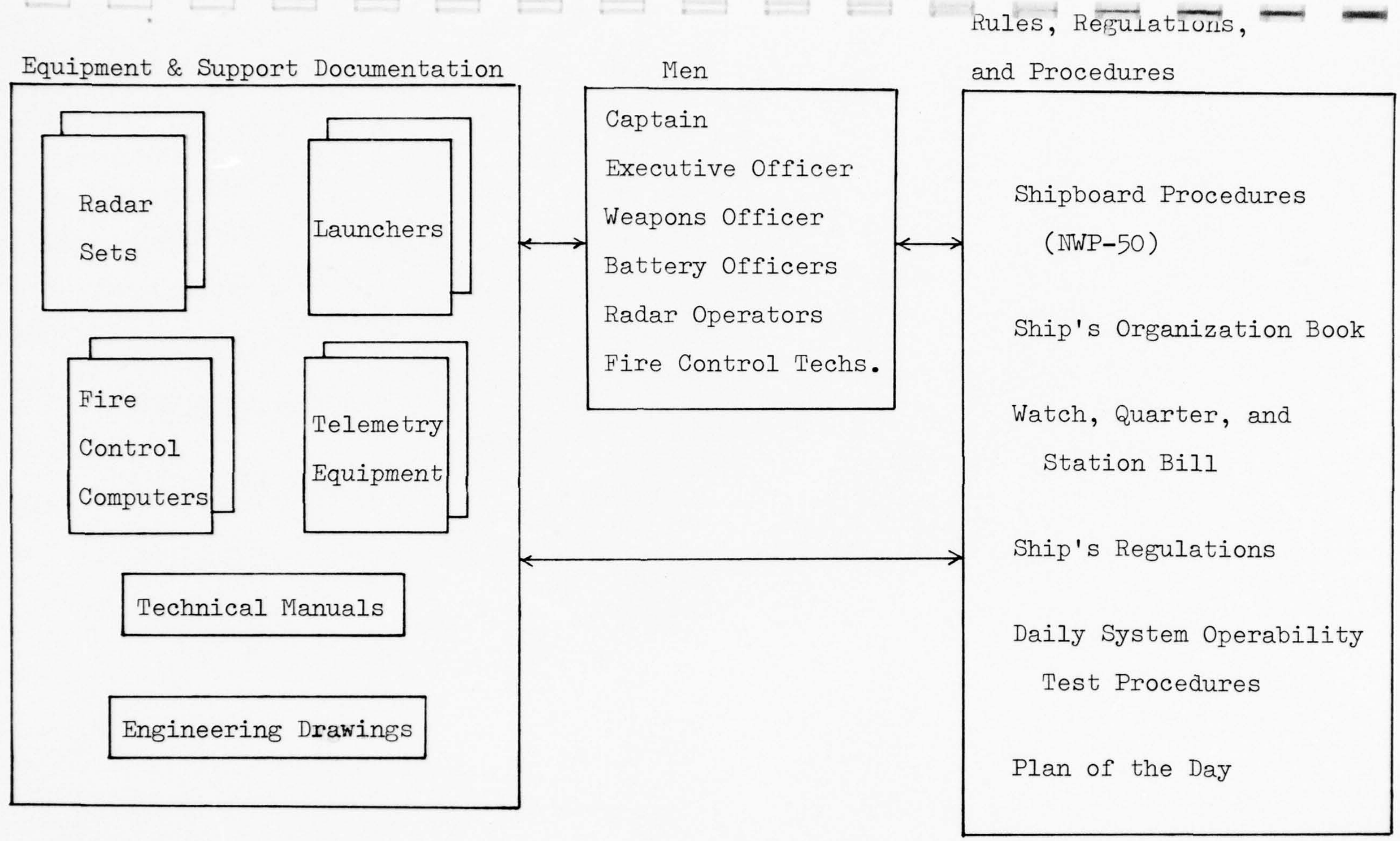


FIGURE 5: THE TECHNICAL SUBSYSTEM

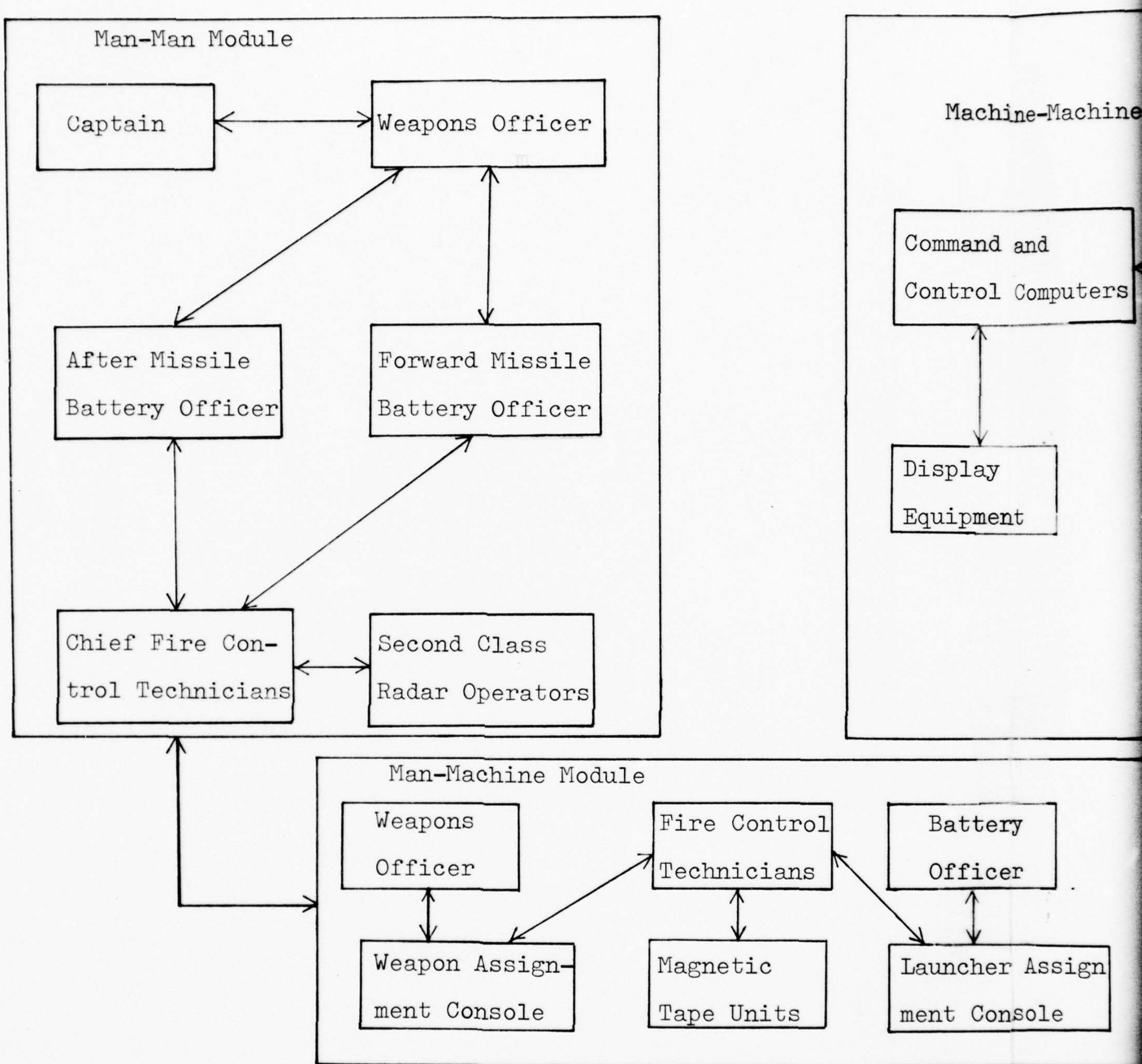
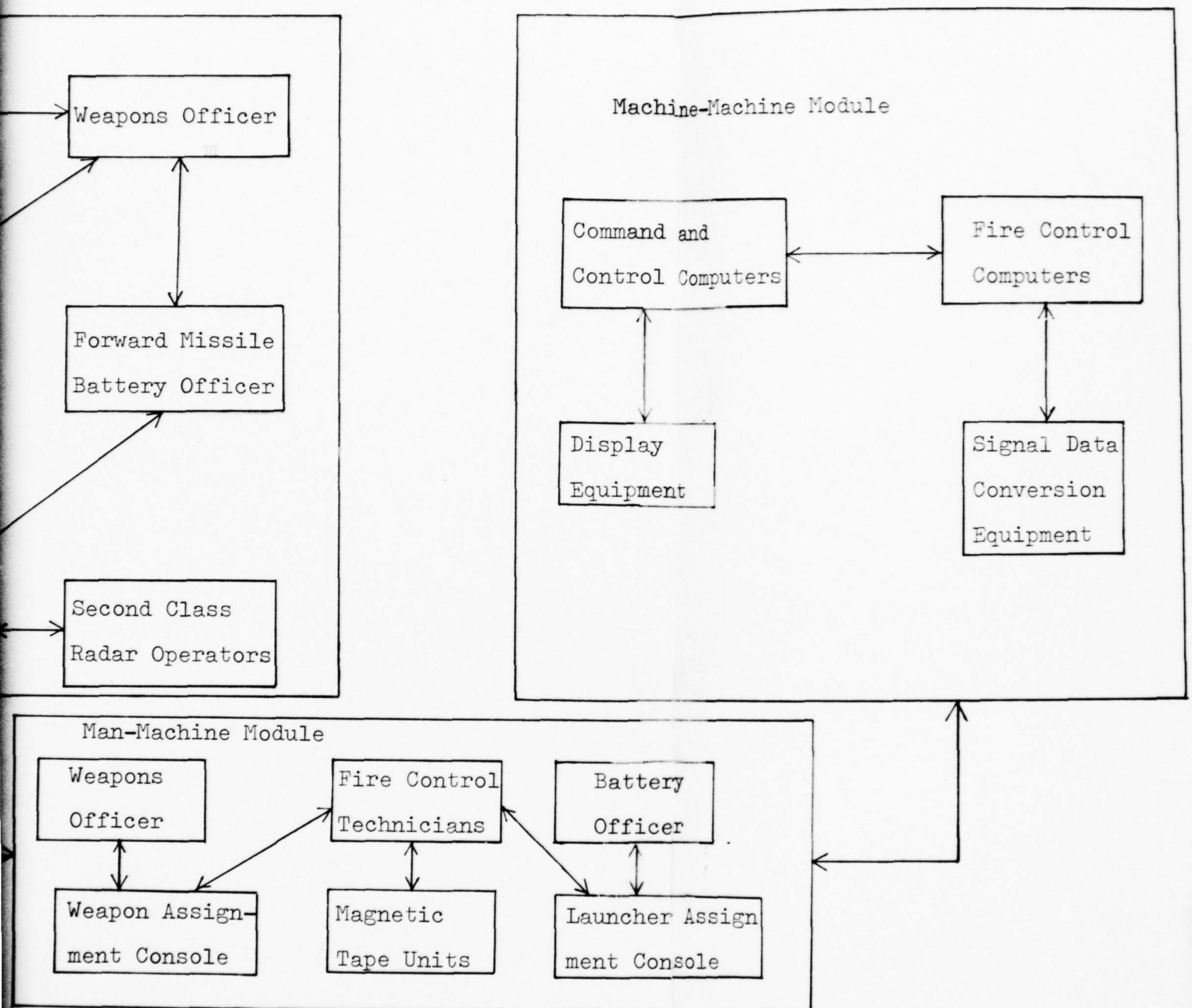


FIGURE 6: THE COMMUNICATIONS SUBSYSTEM



MMUNICATIONS SUBSYSTEM

2

. machine-machine

The man-man module refers to communications amongst all men involved in the shipboard combat system. Both dyad and small group communications are included. Orders from the Captain to the Weapons Officer concerning target engagements, reports from Battery Officers to the Weapons Officer regarding readiness of weapon systems, and equipment test reports from Chief Fire Control Technicians to Battery Officers are typical here. In this subsystem communications are vocal, written, and visual.

The man-machine module includes all those men within the combat system who interact with machinery related to the combat mission. This module includes communications between radar operators and acquisition-tracking oscilloscopes, Battery Officers and launcher assignment consoles, fire control technicians and input-output consoles, and Weapons Officers and target tracking display equipment.

The machine-machine communications module is concerned with information and data flow between machines associated with the combat mission. Of prime importance here are computer to computer communications since that interface is the least understood and considered.

<u>Principles of the communications subsystem</u>. Koontz and O'Donnell define communications as " . . . intercourse by words, letters, symbols, or messages; and as a way that one organization member shares meaning and understanding

with another."[8] The Koontz and O'Donnell definition and the "Ten Commandments of Good Communication" of Richards and Nielander[9] provided the framework for description of the operation of this subsystem. Consequently, a single set of principles describing an ideal communications system was developed and used to describe the operation internal and external to the communications subsystem of the model automated combat system. The principles developed are:

. Data/information are identified clearly before transmission — adequate planning including consultation with others which considers the goals and attitudes of the receiving organization members is accomplished.

. The purpose of any message is examined prior to transmission — the sender will reflect on his intended accomplishment of any communication.

. The communication will reflect consideration of the total environmental setting — vocal communication effective during in-port test and checkout periods may well prove ineffective during battle conditions.

. The sender is, to the extent practicable, aware of overtones as well as basic content of the message transmitted.

. When possible, and on a not-to-interfere basis with higher priority communications, an organization member

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8. Harold Koontz and Cyril O'Donnell. Principles of Management: An Analysis of Managerial Functions, (Hereinafter referred to as Principles of Management), Mc-Graw-Hill Book Co., New York, 1968, p. 590.

9. Max D. Richards and William A. Nielander. "Ten Commandments of Good Communication," Readings in Management, South-Western Publishing Co., Cincinnati, 1958, pp. 141-3.

transmits information of value to another organization member.[10]

. The sender follows up on his transmissions; in particular, high priority messages require feedback from the receiver.[11]

. The actions of an organization member support his communications.[12]

. An organization member tries to understand as well as be understood — he is a good listener (receiver,) not only a good speaker (sender.)[13]

<u>The Behavioral Subsystem</u>

The behavioral subsystem is comprised of the following three modules, each of which has two discrete elements:

- human behavior
  - one-on-one
  - small groups
- machine behavior
  - one-on-one
  - small groups
- man-machine behavior
  - man-on-machine
  - men and machines

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10. *Ibid.*
11. *Ibid.*
12. *Ibid.*
13. *Ibid.*

The one-on-one elements include man-on-man (human behavioral module,) machine-on-machine (machine behavior module,) and man-on-machine (man-machine behavior module.) The small group elements include men (human behavior module,) machines (machine behavior module,) and men and machines (man-machine behavior module.) In this paper a small group refers to three or more units (men and/or machines) which share common objectives, values and norms, satisfy an unwritten set of membership criteria, and are organized informally according to a stable differentiation of roles.[14]

The segmentation of each module into the two elements of one-on-one and small group is important for several reasons. First, any member of a combat system (model or otherwise) is involved in different small groups for relatively long periods of time; e.g., a Chief Fire Control Technician is part of the ship's enlisted men, fire control technicians, weapons personnel, and Chief Petty Officers for the duration of a ship's deployment. Small group memberships are transient to the extent that personnel are reassigned and memberships increase or decrease somewhat but the existence of small groups remains unaffected. Some small groups, like officers and enlisted men, are always evident; other ad hoc small groups, like a combat system "tiger team," are apparent only when the need arises. Any individual member, then, is always part of many small groups at any

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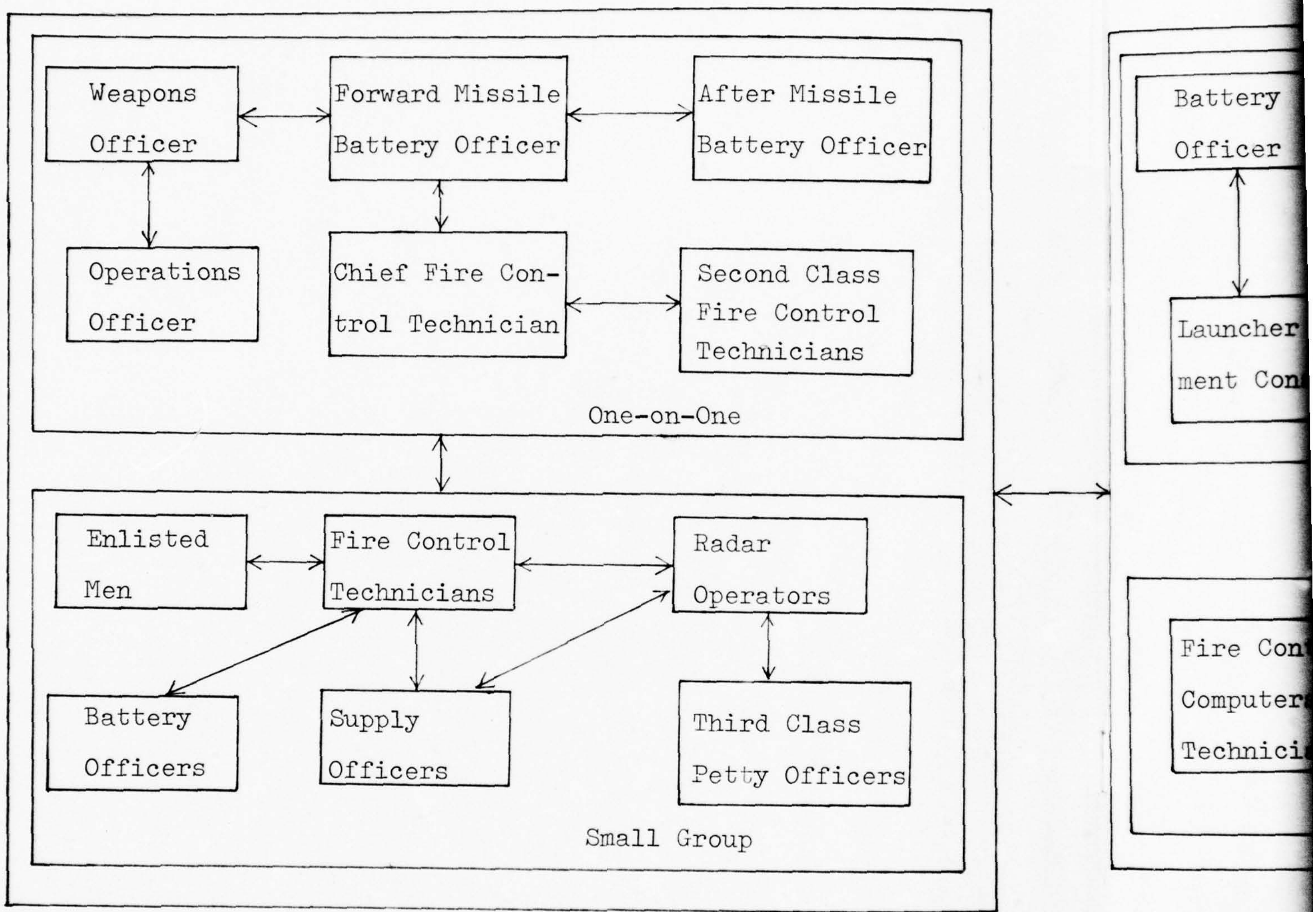
14. Clovis R. Shepherd. Small Groups, Chandler Publishing Co., Scranton, 1964, p.5.

point in time and his behavior is affected or manifested accordingly. However that same member is also involved in one-on-one situations with individuals who may or may not be members of the same small groups. His behavior in those situations is usually affected or manifested different from his behavior as a small group member. As Sutermeister points out, "Behavior is governed, not by 'objective' facts, but by facts as perceived by individuals . . . each of us sees the world in a manner slightly different from anyone else. These differences give rise to the unique individual personality."[15] In one-on-one situations the individual personality and perceptions predominate. While small groups depend on uniformity of individual perceptions, the synergistic personality and perceptual tendencies of the group will be different from and predominate individual members' traits. Further, Sutermeister notes that " . . . members of one group see the facts in one way, members of an opposing group see them differently."[16] In summary, it is important to recognize that an individual member of an organization behaves according to his status and the situation: in one-on-one interactions his own personality and perceptions dominate; in interactions between small groups, the group personality and perceptions predominate. Figure 7 illustrates typical actions and interactions of the subsystem modules.

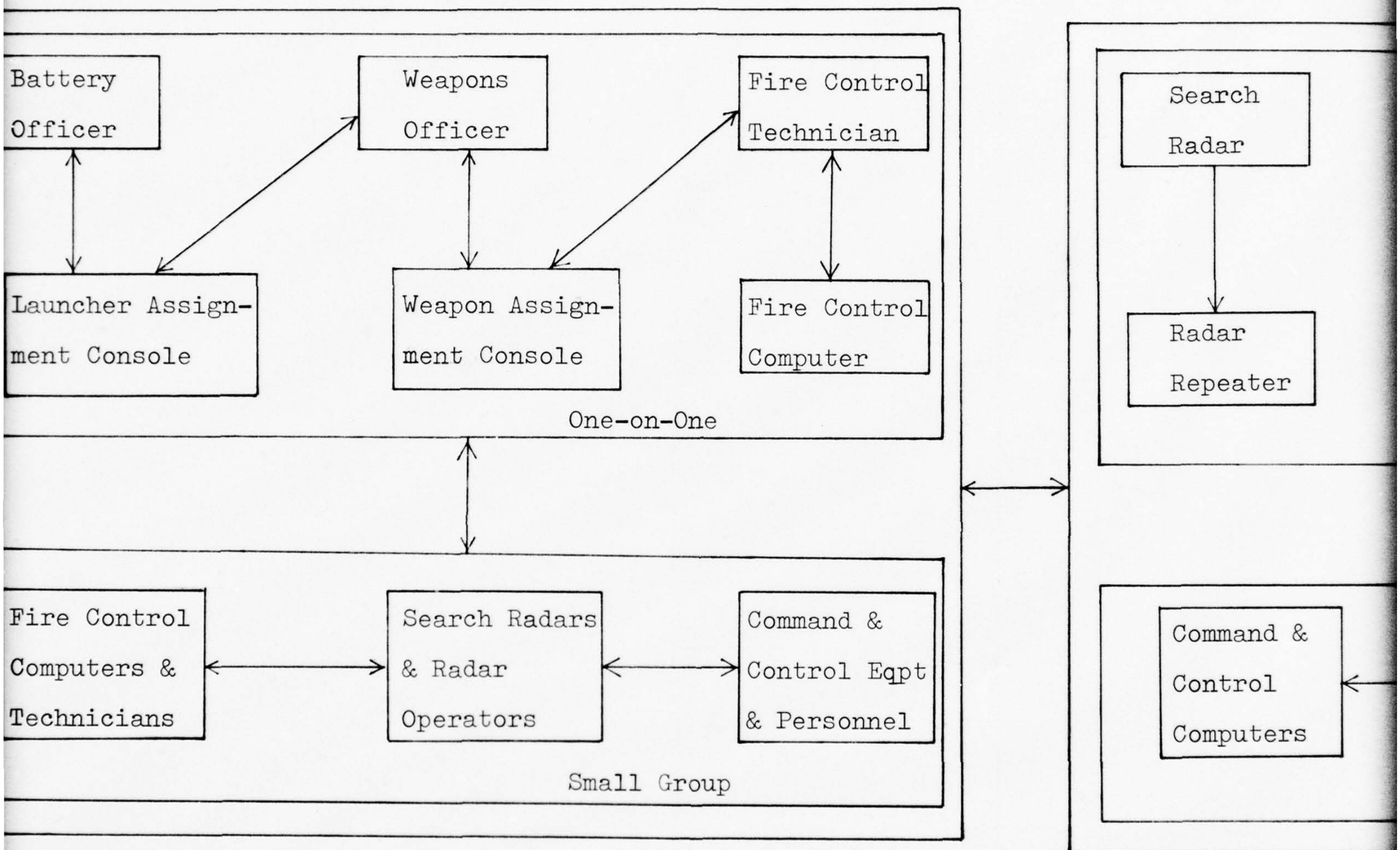
15. Robert A. Sutermeister. People and Productivity, McGraw-Hill Book Co., New York, 1969, p. 143.

16. Ibid.



Human Behavior Module

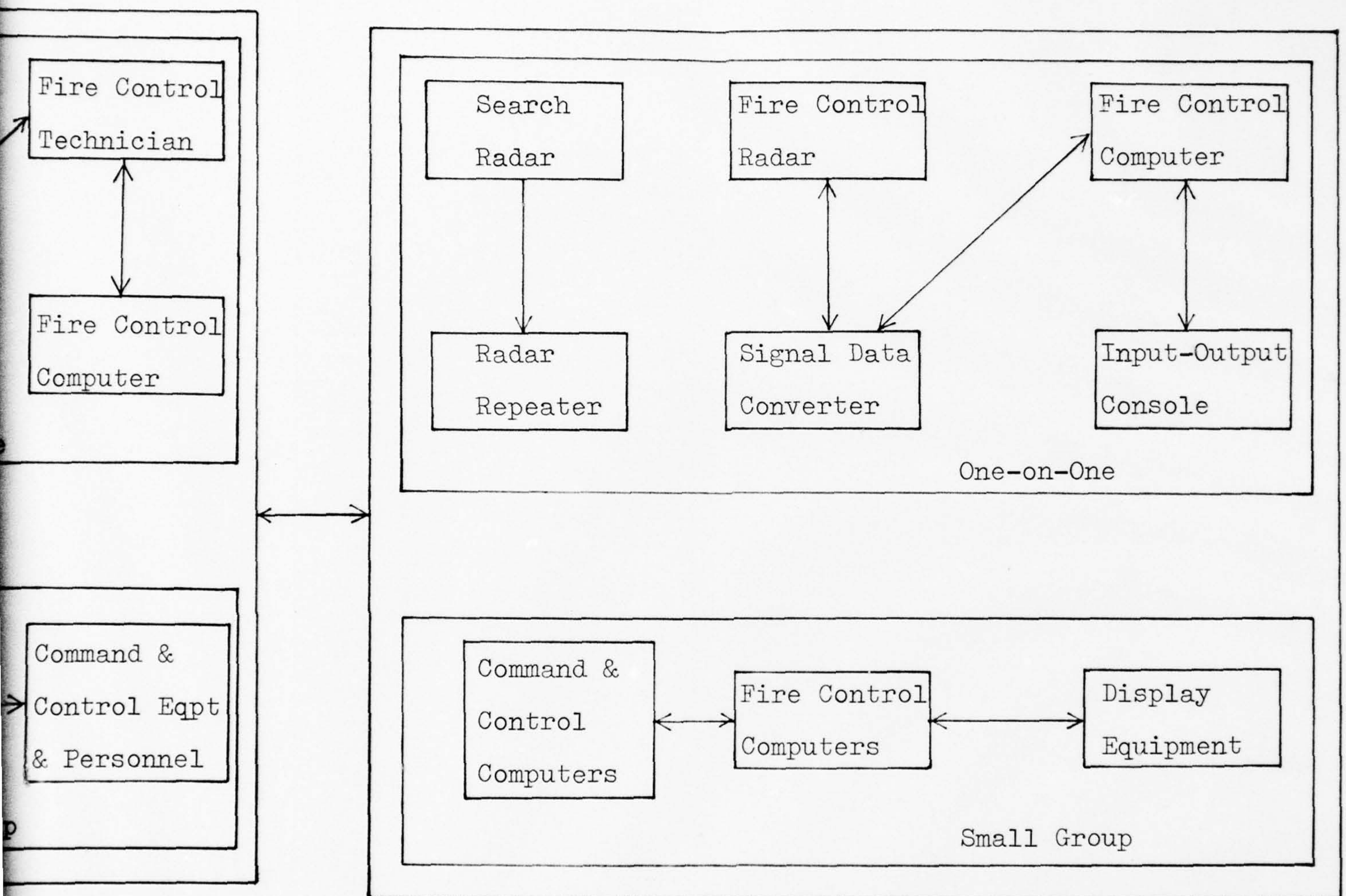
FIGURE



Man-Machine Behavior Module

FIGURE 7: THE BEHAVIORAL SUBSYSTEM

2



odule

Machine Behavior Module

3

Guidelines of the behavioral subsystem. The actions and interactions of the behavioral subsystem of the model automated combat system are, like the technical subsystem, predicated on healthy men and fully operable equipment. With that condition, the now classic theses of Maslow and McGregor and the postulates and conclusions of Koontz and O'Donnell, Herzberg, and Argyris provided the structure for the model behavioral subsystem.

To describe the operation of a behavioral system it is first necessary to study the nature of its elements. In the words of Bertram Gross, " . . . purposeful behavior . . . is motivated by a multiplicity of interests . . . The relation between various interests, however, is extremely complex."[17] The hierarchy of needs developed by Maslow provides the means to deal with that complexity.[18] Behavior may then be analyzed or interpreted in terms of needs satisfaction.

The nature of man is further revealed by his perceptions. Man's perceptions or, more accurately, perceptual distortions were already mentioned in the discussion of small groups. Possible perceptual differences might be quantized as infinite but McGregor's Theory X/Theory Y assumptions of man[19] are of great value since they provide

17. Bertram M. Gross. The Managing of Organizations, The Free Press of Glencoe, New York, 1964, p. 321.

18. Abraham H. Maslow. Motivation and Personality, Harper and Row, Publishers, Inc., New York, 1954, Chap. 4,5,&8.

19. Douglas McGregor. The Human Side of Enterprise, McGraw-Hill Book Co., New York, 1960, Chap. 3 & 14.

the extreme boundaries of man's possible perceptions of man.

Man's nature as a unique individual personality was already addressed. (See the Sutermeister reference, footnote 15 of this chapter.) Koontz and O'Donnell summarize this aspect of the nature of man: "Attempts to take the square root of mankind, on the assumption that people are all alike, are bound to fail. People are not all alike. Natures are different and, for the individual, his nature may differ from time to time."[20]

Koontz and O'Donnell also address two aspects of man's nature that are implicit in Maslow's needs hierarchy. First, they feel that an " . . . individual wants to live and work in a social environment."[21] It is true that some men prefer environments of solitude, (this seems particularly true for scientists,) but there is no place for those individuals in a model combat system. Second, Koontz and O'Donnell state that the " . . . individual helps to create institutions to serve the needs of their memberships. There are many needs that man alone cannot satisfy. He can achieve them only through cooperative effort."[22] As Sutermeister points out, managers might utilize this participative nature of man to advantage since subordinates may accept final decisions more readily, feel more enthusiastic and responsible

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20. Koontz and O'Donnell. Principles of Management, p. 545.
21. Ibid.
22. Ibid.

about their work, and resist change less.[23]

Herzberg identified two aspects of the nature of man, his " . . . animal nature — the built-in drive to avoid pain from the environment, plus all the learned drives which become conditioned to the basic biological needs."[24], and the growth nature, " . . . that unique human characteristic, the ability to achieve and, through achievement, to experience psychological growth."[25] On this thesis, which is very similar to Maslow's, and a series of 17 related studies Herzberg hypothesized a motivation-hygiene theory of job attitudes.[26] He concluded that "The stimuli for the growth needs are tasks that induce growth . . . they are the job content. Contrariwise, the stimuli inducing pain-avoidance behavior are found in the job environment. The growth or motivator factors that are intrinsic to the job are: achievement, recognition for achievement, the work itself, responsibility, and growth or advancement. The . . . hygiene . . . factors that are extrinsic to the job include: company policy and administration, supervision, interpersonal relationships, working conditions, salary, status, and security."[27] The work of Herzberg provides a sound basis for

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23. Sutermeister. People and Productivity, p. 43.

24. Frederick Herzberg. "One more time: How do you motivate employees?," (Hereinafter referred to as "One more time"), Harvard Business Review: Human Relations Series Part II, Reprint No. 21096, p. 119.

25. Ibid.

26. Frederick Herzberg, F. Mausner, and B.B. Snyderman. The Motivation to Work, John Wiley and Sons, Inc., New York, 1959.

27. Herzberg. "One more time," p. 119.

getting things done through people.

One final aspect of man's nature is worthy of mention; viz., the perceived behavior of the ultimate superior or CEO, the Chief Executive Officer,[28] as Argyris calls him. "The way the CEO actually behaves is crucial . . . It is his behavior (and subsequently that of other officers) that ultimately does or does not confirm the idea that organizational development is necessary, credible, and inexorably linked to leadership style."[29] If the CEO's behavior is perceived as negative in any sense, organizational effectiveness suffers. The importance of man's perception of his CEO, be it right or wrong, cannot be overstated. One has only to reflect on the impact of the word "Watergate" on his peace of mind.

Based on the references cited above, the following set of guidelines describing the operation of the model behavioral subsystem was generated: (In what follows, "element" refers to both man and machine.)

. An organizational element recognizes the universality of Maslow's needs hierarchy — The needs to survive, belong, command respect, and self-actualize are felt in varying degrees by all elements, and I do mean to include machines here. A machine's needs refer to its design and interface requirements. While they are limited relative

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28. Chris Argyris. "The CEO's behavior: key to organizational development," Harvard Business Review, March-April 1973, p. 56.

29. Ibid., p. 64.

to the needs of men, they are needs nonetheless and must be satisfied if model performance is expected. (If machine needs are underplayed the overall goals and objectives of a combat system will not be met.)

- Each organizational element is unique but the synergistic personality or characteristics of small groups of which an element is a member do not differ significantly from its own; i.e., within the model subsystem, small groups and their individual members perceive in virtually identical manner.

- Organizational elements participate in the creation of the model combat system and support it to the fullest of their capabilities.

- Organizational elements wish to work in a social environment.

- Organizational elements can be motivated to get the combat mission done. Motivator factors dominate hygienic factors.

- The Captain's behavior is perceived by organizational members as consistent with organization goals and objectives.

CHAPTER III: PERFORMANCE TESTS

As noted in Chapter II, a comparison of actual combat system performance to model performance under similar circumstances is necessary to highlight the most serious symptoms of present shock. If, as Kepner and Tregoe suggest, one compares what should be to what actually is, the identified deviation(s) defines the problem(s) to be solved.[1] By application of the same stimuli to a model system and actual systems one is then able to describe what should happen (from his model statements) and what has happened (from observations.)

In this chapter two different sets of stimuli, or tests, are presented for use as inputs to the model automated combat system. These tests are based on standard shipboard situations for which extensive historical data exist. The intent of these tests is to provide ideal combat system performance data against which historical real-world combat system data may be compared. The two tests are:

- Target Tracking Exercise
- Casualty Reporting Exercise

TARGET TRACKING EXERCISE

This test involves the at-sea tracking of a live airborne target equipped with electronic countermeasures (ECM.) The test consists of tracking a B-47 airplane equipped with

1. Charles H. Kepner and Benjamin B. Tregoe. The Rational Manager, McGraw-Hill Book Co., New York, 1965, p. 47.

jamming devices flying the prescribed pattern shown in Figure 8. The actual test starts when the plane and ship are at points A and A' respectively. The plane flys the race-track pattern three times; the relative velocities of plane and ship are such that the ship is at point B when the plane is back at point A starting its second run and the ship is at point C when the plane is at point A starting its third run. During its first run, the plane flys the pattern using no countermeasures; during its second run the plane turns on a C-band jammer early in its southward leg and keeps it on until early in its northward leg; during its third run the plane employs cyclic jamming throughout the southward leg. During each southward leg the ship engages the plane via a simulated firing and data are collected throughout the test in the search radar, command and control, and weapon fire control system spaces. Post-test data reduction and evaluation are performed to ascertain integrity of data flow "from sensor to bullet" and assess the combat system effectiveness against the three different targets; i.e., no ECM, continuous jamming, and cyclic jamming.

CASUALTY REPORTING EXERCISE

The purpose of this test is to observe the performance of the model automated combat system in reporting a casualty. This test is predicated on the following assumptions:

1. A fire control computer associated with a missile battery has malfunctioned.

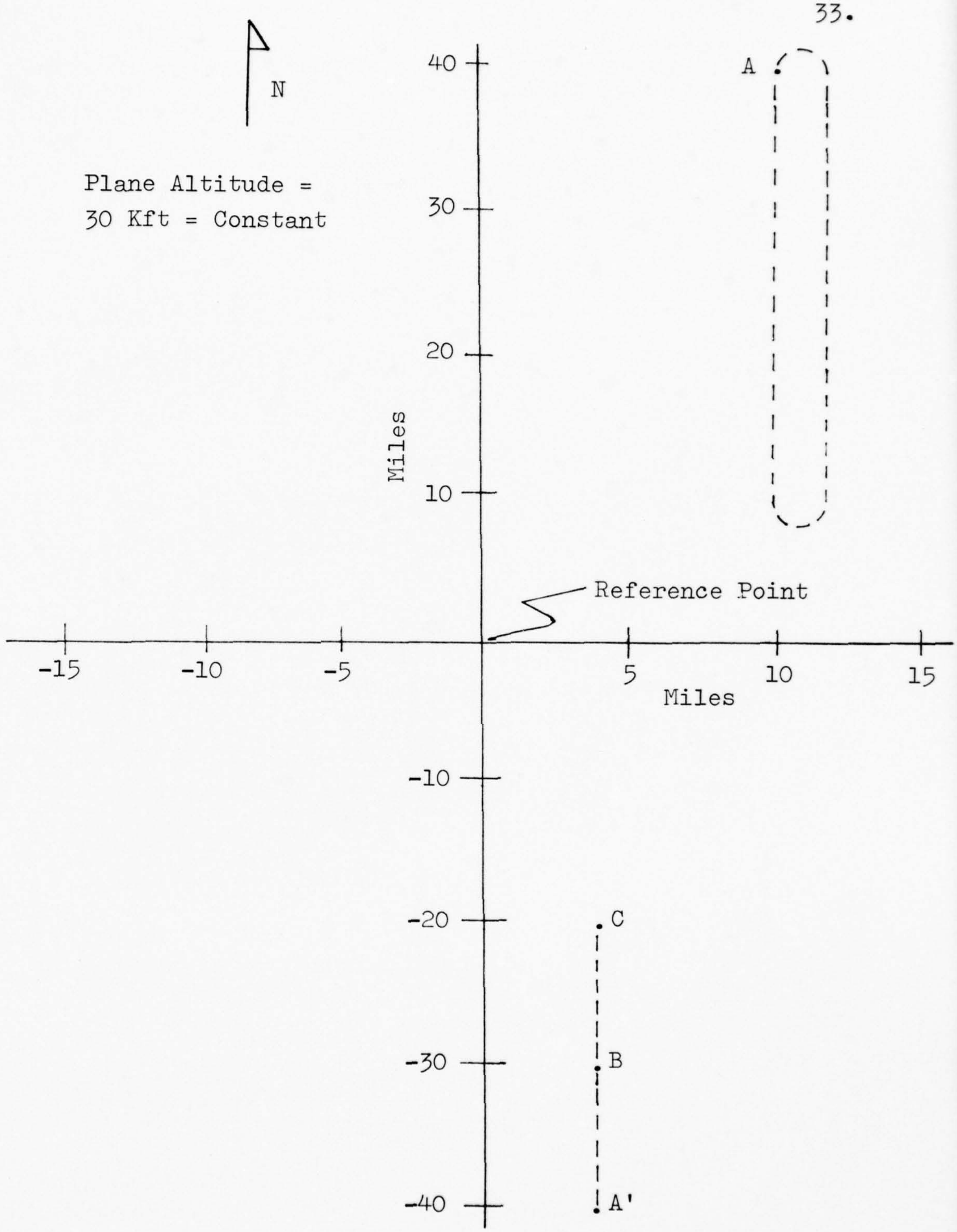

FIGURE 8: TARGET TRACKING EXERCISE: TARGET FLIGHT PATH AND SHIP'S HEADING

2. The malfunction has been identified as transmission of erroneous data; specifically, one target range word is occasionnally in error, and

3. The source of the error has been diagnosed to a specific memory stack.

The exercise requires filling out and transmitting a CASREP form in accordance with the principles and guidelines of the model automated combat system. The CASREP to be filled out must include the following information:

- Identification of the malfunctioning equipment,
- A statement of the ship's present assignment and the impact of the casualty on the ability of the ship to carry out its present assignment,
- Estimated time to repair the casualty,
- A detailed explanation of what problem(s) was exhibited and the environment at the time,
- The cause of the problem(s) if known or suspected,
- Special assistance, equipment, or spare parts required,
- Status of corrective actions already taken, if any,
- The ship's schedule for its present deployment.

CHAPTER IV: MODEL AUTOMATED COMBAT SYSTEM TEST RESULTS

In this chapter the performance of the model automated combat system of a surface combatant ship when subjected to the tests of Chapter III is described. The performance description is presented in terms of how the model system accomplished the goals and objectives of each test since, by intention, it is assumed that the model system operated so that the purpose of each exercise was entirely fulfilled.

In the Target Tracking Exercise model system performance is described by the actions taken by the system members. It is assumed that the exercise was a comprehensive test of the model system's reaction to three different, potential targets and that the system demonstrated the ability to carry out its intended tactical mission. Therefore model system performance here defines the ideal performance attainable by real-world systems.

In the Casualty Reporting Exercise model system performance is portrayed by a filled-in CASREP form. The purpose of this test is to produce an ideal CASREP; i.e., one which defines a casualty accurately and completely, is transmitted appropriately, and followed-up expeditiously. In so doing the reporting ship is fulfilling the basic intent of the CASREP system; i.e., assessing accurately its ability to carry out its intended mission.[1]

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1. NAVMATINST 4000.23: Fleet Casualty Report data within NMC, consolidation and processing of

TARGET TRACKING EXERCISE RESULTS

Prior to the actual running of this exercise, the following actions were taken:

1. Starting one week prior to the exercise, combat personnel performed a daily system operability test of the combat system to assure a full operability status. (In this ideal environment it is assumed that all equipments were fully operable.)

2. One week prior to the exercise the Weapons Officer met with key subordinate combat system officers; e.g., Command and Control Officers, Battery Officers, and Warrant Officers rated for combat system duty, and passed out copies of the Target Tracking Exercise Test Procedure. The goals and objectives of the exercise were identified and specific roles and actions were discussed and modified.

3. Six days prior to the exercise the Battery Officers, Command and Control Officers, and officers in charge of search radars met with subordinate personnel, passed out copies of the Test Procedure, and explained the test objectives. The specific roles and actions of each participant were discussed and modified and personnel, including backups, were assigned to each role. Data recording actions were particularly stressed; e.g., recorder speeds were identified, manual entries on recorder paper were standardized, and data record verification procedures were stipulated.

4. Three days prior to the exercise the Weapons Officer

met with the officers of action 2 above, discussed crew feedback concerning the Test Procedure, and finalized that document.

5. Two days prior to the exercise the Weapons Officer met with the pilot of the target aircraft, informing him of the purpose of the test and its importance in assessing combat system effectiveness; in particular, the goals and objectives of the exercise were made clear to the pilot. The following items were discussed in detail:

- The intended target flight path and ship's speed and course,
- ECM employment,
- Contingency flight paths and changes in ECM tactics if:
  - weather conditions precluded flying the intended course,
  - other ships' exercises precluded flying the intended course,
  - C-band jammers malfunctioned,
  - sufficient data for the purposes of this exercise were taken on the first two runs.
- A set of coded, terse vocal commands and responses for use during the exercise itself.

Actual running of the test took place at the time intended and the exercise was carried out as planned. The Weapons Officer/pilot communications effected complete aircraft control by the ship. No equipment malfunctioned during the exercise, weather conditions were ideal, no interference from own ship, other ships, or aircraft was experienced, and all data records were verified for completeness and suitability for post-exercise reduction, correlation, and evaluation.

Post-test data reduction of data collected on magnetic tape in the search radar, command and control, and fire control spaces was performed using a data reduction computer program run on a command and control computer. The reduced data were presented on hard-copy teletypewriter paper and formatted for ease of correlation and evaluation. The evaluation procedures included in the Test Procedure were employed and the Weapons Officer concluded that the test data from the various combat system subsystems exhibited very close correlation (within the rounding accuracy of the computer) and indicated perfect system operation; i.e., acquisition of each target by the designated fire control radar within five seconds of weapon direction, solid tracking throughout the flight, proper ECCM employment when required, and "direct hits" during simulated missile engagements.

Following the exercise the Captain addressed the entire crew via the ship's public address system briefly highlighting the nature of the test, the model combat system performance, the impact of that performance in assessing the ability of the ship to do its job, and the demonstrated value of the ship to its flotilla and fleet.

CASUALTY REPORTING EXERCISE RESULTS

Prior to CASREP initiation, it is assumed that ship's force did the following sequential actions:

1. performed the daily system operability test and observed defective data,

2. stopped testing and, from the nature of the data and the step in the Test Procedure where the defective data were observed, identified suspect subsystems (Command and Control subsystem and Missile Fire Control subsystem,)

3. performed the troubleshooting procedures stipulated in each suspect subsystem's technical manual; e.g., Ordnance Pamphlet (OP,) and identified the responsible subsystem (fault traced to the subsystem (Missile Fire Control) level) and the malfunctioning equipment within the subsystem (fault traced to the equipment (Missile Fire Control Computer) level,)

4. performed the troubleshooting procedures stipulated in the responsible equipment OP and identified the responsible module (fault traced to equipment module (memory bank) level) and the specific malfunctioning part within the module (fault isolated to defective part (memory stack,))

5. verified that the required spare part was not in ship's supply or in other immediately accessible supply sources; e.g., neighboring ships, resupply ship.

The following CASREP was initiated and transmitted 4-15-72, 1550 hours in accordance with the Ship's Organization Book:

CASREP 15721550Z

ALPHA: Equipment requiring repair: Digital Computer (DC) Mk 000 Mod 1, S/N 12.

BRAVO: Ship presently deployed Mediterranean Sea (Sixth Fleet,) able to carry out present assignment.

CHARLIE: On receipt of required spare part, estimated time to repair casualty is 15 minutes.

DELTA: Daily System Operability Test (DSOT) run 4-15-72, 0830 hours refers:

1. Input-Output Console (IOC) Mk 00 Mod 2, S/N 71 printout read 76.8 Kyd for Subtest 1, Step 4c. Specified value is 89.6 Kyd.

2. Ran OP 1234A Fault Isolation Procedure 4 (page 5-61) to completion; verified proper Command and Control subsystem performance.

3. Ran OP 0001 Fault Isolation Procedure 3 (page 5-12) to step 7y; indicated TARZAN Missile Fire Control Subsystem fault. (Step 7y output at Fire Control Computer Status Panel should be 1111111111; was 1111011111.) Ran Step 7y-6; indicated Fire Control Computer S/N 1 malfunction. (Step 7y-6 output at Fire Control Computer Status Panel indicated intermittent blinking light for bit no. 5.)

4. Ran OP 0005B Fault Isolation Procedure Memory Test

no. 2 to Step 17; indicated memory bank no. 1 malfunction. Ran Step 17-3; indicated memory stack no. 3 fault. (Step 17-3 output at Fire Control Computer Status Panel should be 11111111111111111; was 11111111111011111.)

5. At time of test:

a. Room temperature was 15°C, no fluctuation

b. Room relative humidity was 28%, no fluctuation

c. Ship anchored in calm sea offshore CORFU

d. No unusual activity; e.g., welding or deck-plate drilling in computer space

e. No unusual circumstances; e.g., equipments moved against bulkheads to facilitate false deck removal for cable rework in computer space

ECHO: Suspected cause of problem is cracked magnetic core associated with word no. 0076 of memory stack FSN-A5970-00-3000 S/N 414.

FOXTROT: Spare part required: Memory Stack FSN-A5970-00-3000. No special assistance or equipment required.

GOLF: Fire Control Radar S/N's 1 and 2 normally connected to Fire Control Computer S/N 1 casualty switched to after Fire Control Computer S/N 2; forward battery capability preserved.

HOTEL: Ship's schedule:

Inport CORFU 4-14-72 thru 4-18-72

Depart CORFU 4-19-72

At-sea exercises 4-19-72 thru 4-23-72

Inport ATHENS 4-24-72 thru 4-25-72

Depart Athens 4-26-72

At-sea exercises 4-26-72 thru 4-30-72

Inport ATHENS 5-1-72 thru 5-17-72

Depart ATHENS 5-18-72

At-sea exercises 5-18-72 thru 5-22-72

Inport TARANTO 5-23-72 thru 6-1-72

Depart TARANTO 6-2-72

At-sea exercises 6-2-72 thru 6-4-72

Inport BARCELONA 6-5-72 thru 6-8-72

Depart BARCELONA 6-9-72

Arrive CONUS (NOB Norfolk) 6-18-72

On 4-17-72, 0900 hours the following SITREP was initiated in accordance with the Ship's Organization Book:

SITREP 17720900Z April

CASREP 15721550 refers.

ALPHA: No change

BRAVO: No change

CHARLIE: No change

DELTA: Ran OP 0005B Fault Isolation Procedure Memory Test no. 5 five each times at 15°C, 10°C, and 8°C room temperatures (relative humidity constant at 28%.) Malfunction reported in referenced CASREP paragraph DELTA-4 occurred three times at 15°C, four times at 10°C, and five times at 8°C. Other environmental conditions: no change.

ECHO: No change

FOXTROT: No change

GOLF: No change

HOTEL: No change

On 4-18-72, 0930 hours the required spare part was received, installed by 1000 hours, and the following CASCOR was initiated and transmitted by 1100 hours in accordance with the Ship's Organization Book:

CASCOR 18721100Z April

Reference A: CASREP 17521550

Reference B: SITREP 17720900Z April

Casualty reported references A and B corrected 4-18-72, 1000 hours.

CHAPTER V: PRESENT SHOCK OF ACTUAL AUTOMATED COMBAT SYSTEMS: THE DIAGNOSIS

This chapter includes a summary presentation of actual automated combat system performance in environments statistically similar (no significant differences) to the exercises described in Chapter III, a comparison of that performance to model performance as described in Chapter IV, and tabulations of the identified dominant symptoms of present shock as exhibited by the automated combat systems in fleet operational use today.

ACTUAL AUTOMATED COMBAT SYSTEM PERFORMANCE

The performance documented here is based on historical data and subjective judgments. The historical data referring to target tracking exercises were derived from Development Assist Test (DAT) reports, Ship's Qualification Test (SQT) reports, and DSOT records from cruisers carrying TALOS missiles, frigates carrying TERRIER missiles and 5" guns, and destroyers carrying TARTAR missiles. A total of 76 reports encompassing 186 discrete exercises comprised the data base used here as representative of actual automated combat system performance relative to target tracking. The historical data referring to casualty reporting effectiveness were derived from 30 CASREP's, each addressing a fire control computer or fire control computer program malfunction. Again, the weapons systems selected as typical here were TALOS, TERRIER, and TARTAR.[1] The subjective judgments referring to both exercises were predominantly my own based on my observations over the last 12 years.[2]

Target Tracking Exercise

The target tracking performance of automated combat systems in today's surface combatant ships is presented in Table 1. It is significant to note that:

. In the total of 186 exercises: all goals were achieved in only 15 (8%) of the cases; in 37 (20%) of the

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1. These historical data were not presented in quantitative or descriptive form since specific values of tracking parameters were first, irrelevant to the purposes of this paper and second, classified material. Rather, the system performance indicated by the data evaluation was presented in a qualitative summary fashion which was suitable for purposes of comparison to the model performance. If the reader is interested in reviewing the source documentation he should take the following actions:

   a. Submit a request for access to that material to:
      NAVORDSYSCOM (ORD-06)
      Washington, D.C. 20360

   b. Upon verification of need-to-know, contact the writer by mail:
      NAVORDSYSCOM (ORD-551)
      Washington, D.C. 20360
      or phone: 202 692-7898

2. From July 1960 to the present time my job employment has been directly related to U.S. Naval Surface Missile Systems (SMS) weapon systems, and surface combatant ship gun systems. I was employed by Sperry Gyroscope Company of the Sperry Rand Corporation until December 1966; during that time I worked on the TALOS and TERRIER missile fire control systems as a Field Engineer, Product Engineer, and Systems Engineer. From December 1966 to the present time I have been employed by NAVORDSYSCOM; throughout that period my primary duties and responsibilities were concerned with the technical aspects of surface weapon systems (TALOS, TERRIER, TARTAR, and AEGIS missile systems and 5"/54 76mm/62 guns) acquisition.

PERFORMANCE	NUMBER OF TIMES OBSERVED
A. Exercise completed: all goals achieved	11
B. Exercise completed: some goals achieved	28
C. Exercise completed: no goals achieved	9
D. Exercise not completed: all goals achieved	4
E. Exercise not completed: some goals achieved	106
F. Exercise not completed: no goals achieved	28

TABLE 1: TARGET TRACKING EFFECTIVENESS OF ACTUAL AUTOMATED COMBAT SYSTEMS

cases, no goals were achieved at all,

. Only 48 (26%) of the 186 exercises were run to completion,

. Performance was typified by incomplete testing and partial goals achievement (occurred in 106 (57%) of the 186 cases,)

. Model performance; i.e., exercise completed and all goals achieved as described in Chapter IV, was exhibited in only 11 (6%) of the 186 cases.

Comparison of actual combat system performance to model performance shows that only 11 instances compare favorably while 175 do not. In order to identify the reasons for less than model performance and to assess the degrees of incomparability I reviewed the 175 exercise reports for non-conformance with the actions taken by the model system. In this way I identified the following dominant symptoms of present shock exhibited during target tracking situations:

. While DSOT's were performed within 24 hours of the target tracking exercise in all cases, less than 20% of the combat systems were fully operable at the time of the exercise.

. In 70% of the cases, the Test Procedures were inadequate; one or more of the following were evident:

1. Goals and objectives were not clear; e.g., it was common to note a statement like "The goal of this test is to assess the ability of the system to engage long

range targets in an ECM environment." A better statement might have been "A goal of this test is to assess the ability of the system to engage targets (predicted intercepts 65 to 90 miles from the ship) employing continuous and cyclic C-band jamming."

2. Test and personnel set-up requirements were incomplete. Some Test Procedures (7%) specified use of equipment not available on ship. Many Test Procedures (64%) did not completely specify data recording requirements; e.g., recorder speeds were not specified, turn-on times were improperly specified or not specified at all, and manual entries at critical events were not specified.

3. Steps in the Test Procedures were vague. Statements such as "Turn on recorder in fire control computer room no. 2 at target acquisition" mean different things to different people.

. In all 175 exercises pre-test planning was unsatisfactory when compared to model planning. Specifically:

1. In 15% of the cases, there were no meetings at all between the Weapons Officer and his key subordinates. In the remaining 85% where meetings did take place:

a. Goals and objectives were not clear in half the cases.

b. The reasons behind the roles and actions were clear to the key subordinates in virtually all the cases but those reasons were not made clear to the next two levels of subordinates; i.e., the equipment space chiefs and the operating personnel. In 96% of the cases the reasons for the actions of a particular participant (search radar operator, fire control computer technician) were clear to that individual but the reasons behind the actions of the other participants were not clear to any specific individual in almost every case. For example, a search radar operator understood his role, why it was necessary, and the rationale for the actions required of him; however, he had little if any feel for the role of the missile fire control computer technician five decks below and 74 frames aft of him and little understanding of the purpose of that technician's actions; indeed, I have frequently observed a reluctance on the part of many combat system human members to find out what the other members outside their subsystem do and why they do it.

c. In DAT target tracking exercises the meetings with the operating personnel were in 85% of the cases conducted by people not attached to ship's company; e.g., Applied Physics Laboratory/Johns Hopkins University (APL/JHU) personnel, NAVSHIPSYSCOM and/or NAVORDSYSCOM representatives, Naval Ship Weapon Systems Engineering Station (NSWSES) personnel, or contractor representatives. In those cases it was typical to note differences in test goals and objectives as perceived by the APL/JHU, NSWSES, and contractor representatives and as perceived by the ship's crew.

d. A feedback meeting between the Weapons Officer and his key subordinates reflecting crew understanding and inputs occurred in only 10% of the cases.

e. Back-up personnel were rarely assigned and in about 20% of the cases a man performed a task during the exercise for which he was not adequately prepared.

f. Data recording actions were not completely defined in 46% of the cases.

2. Meetings were conducted with the target aircraft pilot in 83% of the cases but, particularly for DAT exercises, not always with the Weapons Officer. It was typical then for the pilots to misinterpret the goals of the exercise. I was once a participant in a DAT target tracking exercise which was intended to assess the capability of a combat system to engage high altitude (40 Kft to 60 Kft) targets employing continuous C-band jamming. The intent of the exercise was to determine combat system effectiveness using search radar data as as alternate source of range information by a missile fire control system whose tracking radar data were unreliable. The exercise started properly with the target aircraft and ship in position according to plan. However, as the exercise progressed it became apparent that major unanticipated combat system problems existed because no reliable target information was gathered. At no time during the exercise was a simulated firing attempted since the combat system did not maintain

a solid target track. At the end of the exercise the pilot informed the shipboard aircraft controller that he had employed all the ECM devices he had available on the plane in an attempt to remain undetected by the ship. He succeeded in that attempt but also succeeded in precluding the ship from achieving the exercise goals. At first the pilot was jubilant; later, he was not. The major point here is he completely misunderstood the goals and objectives of the exercise; the money wasted was enormous, the availability of the target aircraft was abused, and the ship was unsure of its capability against certain targets.

. Environmental conditions were detrimental in 23% of the cases. Interference from either own ship's radiating equipment not concerned with the combat system exercise or from other ships' equipments degraded the test performance.

. In 29% of the cases, erroneous data recording actions were taken; e.g., recorders were not turned on at the proper times, recorders were not calibrated properly, recorders were run at wrong speeds, and hard-copy printouts or recorder paper were mismarked or not marked. The significance of those actions and omissions was data correlation and evaluation was difficult, "guestimated," or impossible.

. On only one of the seven ships in which I actively participated in these exercises did the ship's Captain personally address the crew in relation to the exercise or the crew's performance of the exercise.

Casualty Reporting Exercise

The performance of today's surface combatant ships in reporting automated combat system casualties is summarized in the sections below. The 30 CASREP's constituting the data base here were compared to the model CASREP paragraph by paragraph and the dominant symptoms of present shock exhibited in this exercise were identified. The following sections include a comparison of actual performance to model performance by CASREP paragraph; the final section summarizes the identified symptoms of present shock.

CASREP paragraph ALPHA. The purpose of this paragraph is to identify the malfunctioning equipment; 27 (90%) of the CASREP's did so, 3 (10%) of them used improper equipment nomenclature and although one might surmise the specific piece of equipment, there was reasonable doubt as to exactly what equipment failed. (A personal experience is worth noting here. A ship reported an equipment casualty using the Contractor's S/N (14) instead of the NAVORDSYSCOM S/N (1,) both of which are stamped on the nameplate. Coincidentally, an equipment of the same type but a later configuration had NAVORDSYSCOM S/N 14 assigned. Since the reported problem could have occurred in either equipment but the corrective actions were different due to the configuration variation, the wrong corrective action was recommended to the ship. Follow-on SITREP's led us in NAVORDSYSCOM to identify the appropriate equipment; the proper action was then recommended and the casualty corrected. Fortunately, this situation only cost three days of time during a CONUS in-port period.)

CASREP paragraph BRAVO. The intent of this paragraph is to allow the ship to assess its ability to carry out its present assignment; all 30 CASREP's included a comprehensive statement to that effect although in two cases the assessments conflicted with data provided in subsequent paragraphs.

CASREP paragraph CHARLIE. The intent of this paragraph is to identify the shipboard time required to repair the identified casualty after requisite spare part(s) is onboard; in every case where a required spare part was identified this information was provided, although in one case, the information was inconsistent with the equipment OP.

CASREP paragraph DELTA. The intent of this paragraph is to explain in detail the casualty environment, how the casualty was observed and isolated, and any other pertinent data that might bear on the casualty reported. Comparing actual performance to model performance here indicated extremely poor response to this requirement; only five CASREP's were comprehensive, 15 provided enough data to reasonably read between the lines, but 10 CASREP's omitted information which was obtained later but was available at the time of the reported casualty. Since recommended solutions are often based on the data of this paragraph, one third of these reported casualties required more information from the reporting activity before actual corrective actions could be initiated. In all cases the data provided were not erroneous but, in 10 cases, were insufficient to permit efficient casualty correction.

CASREP paragraph ECHO. The intent of this paragraph is to identify the suspected cause of the problem, if possible. Only five of the 30 CASREP's reported cause unknown. The other 25 identified one or more possible causes and even though some of these proved false, the information was useful to the CASREP action agents.

CASREP paragraph FOXTROT. The intent of this paragraph is to identify the spare part(s), special assistance, or special equipment required for casualty correction. All 30 CASREP's compared favorably to model performance here.

CASREP paragraph GOLF. The purpose of this paragraph is to describe corrective actions taken by the ship. All 30 CASREP's did so but the details of casualty switching; i.e., what equipments were cross-switched, were missing from all but two.

CASREP paragraph HOTEL. The purpose of this paragraph is to identify the ship's movements and activities; all 30 CASREP's complied fully with this requirement.

Present shock in casualty reporting. In summary, comparison of actual combat system casualty reporting to model performance disclosed the following symptoms of present shock:

. Precise identification of malfunctioning equipments was lacking to a significant degree (10% of the time.)

. Narrative information describing the circumstances (technical, human, environmental) prevalent at the time of the casualty reported was incomplete in 25 out of 30 cases.

. Specific casualty configurations were identified in only 2 of 30 cases.

. Sequential, pyramidal troubleshooting as chronicled in the model CASREP was not evident in any of the 30 cases.

. CASREP's followed up by SITREP's were corrected 30% sooner than those which had no follow-up communication. (This symptom was not evident by analysis of the CASREP's themselves.)

CHAPTER VI: PRESENT SHOCK OF ACTUAL AUTOMATED COMBAT SYSTEMS: THE TREATMENT

In the last chapter the dominant symptoms of present shock in real-world automated combat systems were identified. In this chapter the causes of those symptoms are described and recommendations to cure the disease are offered.

CAUSES OF PRESENT SHOCK

On reviewing the symptoms of present shock as listed in Chapter V, I recognized that different symptoms appeared to derive from the same general cause; i.e., a particular cause of present shock was manifested in more than one way. In the following sections this synthesis of symptoms is described and the causes of present shock identified.

Cause No. 1

In 15% of the target tracking exercises, no meetings between the Weapons Officer and key subordinates were conducted — exercise goals and objectives were not clear or perceived differently by small groups within the combat system — resource allocation was inefficient and, in some cases, ineffective — environmental aspects or considerations were not fully anticipated. All those symptoms stem from inadequate planning, the first cause of present shock. This was most apparent in exercises characterized by inefficient and ineffective use of combat system computers. It was also significant to note that the exercises which involved no prior meetings were largely computer-oriented.

Cause No. 2

Goals and objectives of the exercise were not made clear to all participants — the roles and actions of all participants were not apparent to each individual participant — feedback from crewmen up to the Weapons Officer was often absent — identification of equipment was not precise — problem environments were not described comprehensively — relevant data were not perceived as relevant and/or omitted — follow-up communications were atypical. These symptoms are all manifestations of the second cause of present shock; viz., unsatisfactory communications practices. Review of the historical data showed that communications deteriorated with computer participation.

Cause No. 3

Test Procedures did not specify all required actions— Test Procedures specified use of unavailable equipment. Both of these conditions are symptomatic of poor direction, the third cause of present shock. The typical shortcoming here related to digital data gathering, validation, reduction, and evaluation actions, actions directly related to computer utilization.

The Common Thread

Highlighting the causes of present shock in today's automated combat systems as inadequacies in planning, direction, and communications practices probably comes as no surprise to the management conscious person. Indeed in analyzing the problems of any complex system one is invariably led to deficiencies in the basic functions or aspects of management. What is significant though is the common thread which ties the causes of present shock together; viz., the central role of computers. At first it is hard to believe that integration of any single member into a combat system might have such impact on system performance and yet the historical data support that conclusion. And the key questions posed on page 4 re-surface.

CONCLUSIONS AND RECOMMENDATIONS

Having concluded that computers were involved in each cause of real-world automated combat system present shock I feel it insufficient (in fact, almost irrelevant from the viewpoint of this paper) to restate the principles of good planning, direction, and communications. Koontz and O'Donnell[1] among others have covered these topics quite comprehensively. However, it is important to address the relationship of computers to the causes of present shock; i.e., how have computers affected the planning functions, direction functions, and communications aspects of automated combat systems?

Key Questions Answered

On page 4 I cited Toffler's reference to a "complacent

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1. Koontz and O'Donnell. Principles of Management, pp. 81-231 and 537-638.

past-orientation of the race"[2] and questioned whether that orientation affected man-machine interfacing. Based on my personal experience with automated combat systems and the historical data base used in this paper I can now answer that question. First though I must comment on the complacent past-orientation to which Toffler refers. A past-orientation is accurate but to describe it as complacent (as related to combat system personnel) tells only part of the story. Complacency is evident but so too is fear and aversion; and permeating all is ignorance. Ignorance of what the computer does, how it does it, and why it does it is commonplace. An orientation based on ignorance cannot but affect man-machine interfacing negatively. Indeed, logical consequences of such an orientation might be inadequate planning and direction and poor communications as the historical data indicated. I also asked if the situation should be resolved or ignored and allowed to persist. Of course there is only one reasonable answer here; the situation must be resolved if automated combat systems in fleet operational use are required to perform efficiently and effectively. Finally, I asked what could be done to resolve the situation. The remainder of this paper is devoted to answering that question as it relates to real-world automated combat systems.

Present Shock: The Cure

An encapsulation of two ingredients, education and

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2. See Footnote 4, page 4 of this paper.

changes in present management styles, forms the treatment prescribed to cure present shock. Education relates to an increased awareness (or the awakening of awareness) of the utility of computers in combat systems. Education here does not refer to training of technicians in the operation and maintenance of computers; that function is performed well by the Bureau of Naval Personnel; the training required here would address management perceptions of computers as small groups and individual members of combat systems. Since computers are commonplace in today's fleet it might appear that such training really isn't necessary; i.e., officers adapt to changes in equipment as readily as they do to changes in personnel. However, man has always been a part of combat systems and we still have behavioral problems amongst men; computers are a relatively new element in combat systems. And as Shepherd points out, "It is rather strange that people should resist the analysis of the commonplace so stringently since the commonplace is readily accessible and so obviously important."[3] And further, "The self-sustaining nature of social relations means that people resist analyzing the here and now because they may find out that their assumptions and beliefs . . . are not true."[4] Education then must focus on the here and now of computers. " . . . when people do focus on the here and now they often

3. Shepherd. Small Groups, p. 103.

4. Ibid., p. 104.

find the experience rewarding . . . they discover that behavior which they thought was capricious turns out to be meaningful . . . What seems to happen is that the group's cohesion is increased . . . A focus on the here and now may help understanding and may promote desired objectives."[5] With an increased awareness and understanding of computers' roles in combat systems, heretofore complacent past-oriented shipboard officers are likely to modify their management approach so that the accomplishment of combat system objectives is enhanced. Therefore my first recommendation is:

. The Bureau of Naval Personnel should publish a document which highlights the role of the computer in today's combat systems. Technical aspects should be downplayed; reference should be made to technical documents for the interested reader. This document should stress the needs (design and interface characteristics) of computers in both man-machine and machine-machine interactions. (A possible training device might be to fictionalize a computer as a First Class Petty Officer assigned to duty aboard a surface combatant ship. The reader would see the combat system through the eyes of the computer; needs and capabilities might be perceived easier that way. Also, the reader may find it easier to relate to a First Class Petty Officer than an electronic brain.) This document should be required reading for all officers assigned to combat system duty.

5. Ibid.

If the preceding recommendation were implemented, three benefits might be realized:

. Officers' attitudes towards computers might be reflected in a liking vice indifference or dislike for computers. Shepherd has observed that, "People have generalized attitudes toward many social objects, such as labor-union officials, conservatives, Negroes, armed-forces officers, and men who smoke cigars. These generalized attitudes are usually accompanied by feelings of liking or disliking, of attraction or repulsion."[6]

. Increased officer-computer interactions, both dyad and small group, should result. In reviewing Homans' work with small groups, Shepherd concluded that, "Sentiment and interaction are directly related."[7] I feel that this increased interaction would reinforce officer's favorable attitudes towards computers and encourage officers to utilize combat system computers more effectively in their planning, direction, and communications tasks.

. Shipboard officers might maintain an organizational climate more conducive to combat system goal achievement. The role of the computer will have been properly differentiated from the role of man. "In such a group . . . the perception of similarity is tested and, when disagreement exists, a determined effort to resolve it takes place. The

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6. Ibid., p. 60.

7. Ibid., p. 61.

resolution typically is successful and the disagreements are resolved."[8]

Adoption of the first recommendation should result in a shipboard environment more adaptive to its member elements. By itself though, an adaptive environment is not enough. Of equal importance is combat system data handling. Therefore, I recommend the following:

. Requirements for combat system data must be planned to the lowest level of detail practicable, within the capabilities of the available computers.

Considerations here should include determining what data are required to do the jobs and designing the system for easy extraction of that data only, designing the data media for effective communication, and prescribing data formats to assure consistency and avoid misinterpretation. Certainly the computer is the most efficient data handler on a ship but if its needs are not integrated with combat system data requirements it can also prove the most ineffective. Design of combat system data requirements with full consideration of the computers available to the system will promote system goals accomplishment.

My final recommendation hearkens back to the words of Argyris concerning the Chief Executive Officer:

. The Captain of the ship, his Executive Officer, and senior Operations and Weapons personnel must reflect

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8. Ibid., p. 65.

and maintain a climate in which the role of the computer is well differentiated and simultaneously well integrated in the combat system.

If the above situation does not prevail this paper is nothing more than an academic exercise. If though, top-level support nurtures the shipboard climate herein advocated, the thoughts in this paper might provide some insight into the more efficient and effective utility of computers in U.S. Naval combat systems.

APPENDIX I

ASSESSING DEGREE OF AUTOMATION

For each of the computers listed in Figure 3 I assigned a point value based on its power (memory capacity, input-output capability, etc.) and its computer-computer interface capability. I then calculated the total points for each ship and assessed degree of automation as follows:

Total Points	Degree of Automation
0 - 5	Low
6 - 10	Moderate
10 & above	High

For example, the degree of automation of USS CALIFORNIA, DLG(N)-36, was assessed as follows:

Computer	Point Value	No. Onboard	Points
CP-642B	2	3	6
CP-789	1	2	2
Mk 152 Mod 0	1	4	4
Mk 152 Mod 4	1	1	1
			13

APPENDIX II

COMMANDING OFFICER

EXECUTIVE OFFICER		
Aide Personnel Officer Educational Services Officer	Legal Officer Transport Quartermaster *or Transportation Officer* (if applicable)	Ship's Secretary Chaplain Chief Master at Arms

Operations Department	Weapons (or Deck) Department	Navigation Department	Air Department[3]	Engineering Department	Supply Department	Medical Department
Operations Officer Communication Officer Reg. Pub. Officer Signal Officer Radio Officer CIC Officer Intelligence Officer Radar Assistants Lookout & Recognition Officer Antisubmarine Warfare Officer (in ships not having AS armament installed) Aircraft Control Officer *Electronic Repair Officer* Meteorological Officer Communication, Lookout, and CIC Divisions	Weapons Officer[1] Assistant Weapons Officer, Assistant Fire Control Officer and other Assistants First Lieutenant[2] Assistants Aviation Officer in other than carriers & tenders Antisubmarine *Officer* (in AS ships) Marine Officer Main, Secondary & A.A. Battery Divisions Marine Detachment Aviation Division (if no Air Department)	Navigator Assistant Navigators Navigation Division	Air Officer Assistant Air Officer Flight Deck Officer Landing Signal Officer Aircraft Maintenance Off. Ordnance Off. Shops Officer Air Divisions Air Groups Aircraft Squadrons	Engineer Officer Main Propulsion Officer Damage Control Officer Electrical Officer Auxiliary, Repair Boiler, Main Engines, Divisions	Supply Officer *Disbursing Officer* Stores Officer Mess Officer Ship's Store Officer Supply Divisions	Medical Officer Medical Officers as required Medical Division
				Repair Department[4]		**Dental Department**
				Repair Officer Assistant Repair Officers for Machinery, Hull, Instruments, Electronics, etc.		Dental Officer Dental Officers as required

[1] **Head** of Department in ships whose offensive weapons are primarily ordnance or aircraft.
[2] **Head of Department in other types.**
[3] **In aircraft carriers.**
[4] ***In repair ships and tenders.***

FIGURE 1201. Typical ship's organization of a large ship. *

* Reproduced from "The Naval Officer's Guide," p. 340.

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