Technical Research Report 1148

AD

COMMAND INFORMATION PROCESSING SYSTEMS--A HUMAN FACTORS RESEARCH PROGRAM

by SEYMOUR RINGEL

Support Systems Research Laboratory

JUNE 1966

U. S. ARMY PERSONNEL RESEARCH OFFICE

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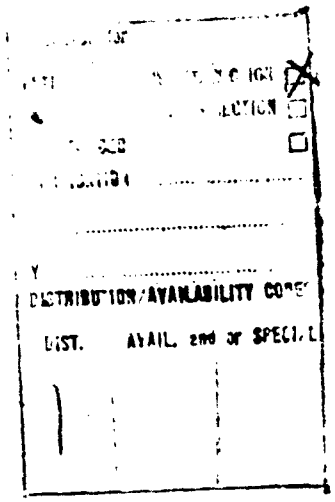

NOTICES

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SUPPORT SYSTEMS RESEARCH LABORATORY
Joseph Zeidner, Chief

U. S. ARMY PERSONNEL RESEARCH OFFICE

Office, Chief Research and Development
Department of the Army

Washington, D. C. 20315

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Army Project Number
2J024701A723

Command Systems Task

USAPRO Technical Research Reports and Technical Research Notes are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The U. S. Army Personnel Research Office has undertaken a comprehensive program of research aimed at increasing the fulfillment of personnel utilization objectives, particularly within the Army's manned systems. The utilization research effort is divided between two approaches, both concerned with enhancing the capabilities of the human factor in Army systems. One approach is characterized by intensive research on specific Army man-machine complexes. A second more general approach is the experimental study of important behavioral functions with the objective of gaining better understanding of these functions and applying the findings across a number of different systems.

The COMMAND SYSTEMS Task seeks to develop research information by which the effectiveness of command information processing systems may be maximized, pursuing its objective through intensive experimentation on manned systems of a specific class. The present publication delineates the scope and structure of the research program and the major subtasks that have been established. A previous U. S. Army Personnel Research Office report, Human Factors Research in Command Information Processing Systems (Technical Research Report 1145), presents a summary of current Task activities.

The entire research Task is responsive to special requirements of the Combat Developments Command, the Army Materiel Command, and the Automatic Data Field Systems Command, as well as to requirements to contribute to achievements under the RDT&E Project 2J024701A723, Human Performance in Military Systems.

J. E. UHLANER
Director of Laboratories

COMMAND INFORMATION PROCESSING SYSTEMS--A HUMAN FACTORS RESEARCH PROGRAM

BRIEF

Requirement:

To present the scope and organization of the research program of the COMMAND SYSTEMS Task as in progress and as projected.

Procedure:

Following a survey of military information processing equipment and operations and plans for command information processing systems, basic human factors problems were identified and organized around five critical operations: screening incoming data, transforming raw data for input into storage devices, input, assimilation of displayed information, and decision making. A research program was formulated comprising six subtasks:

Subtask a. Screening, routing, and expediting operational information.

Subtask b. Methods of data transformation for system compatibility.

Subtask c. Techniques for rapid and accurate information input.

Subtask d. Information assimilation and transfer from displays.

Subtask e. Effective aids in the decision process.

Subtask f. System integration.

Scope of the Report:

The program represents a comprehensive approach to research concerned with automated command information processing systems, ranging from detailed studies of discrete human functions to integration of sizable man-machine complexes--all essential to effectuating field army command systems of high combat effectiveness. The program has an empirical and quantitative orientation and implies a multi-disciplinary effort. It is so formulated that it can be modified as research findings, as well as the developing technology of information processing and the tactical needs for information dictate. Carried to conclusion, the program may enable developers and users to anticipate and avoid many pitfalls in future generations of command systems.

Emphasis currently and for the immediate future is on studies dealing with information assimilation and decision making. Studies on nine major aspects of these functions are delineated. Plans for the remaining subtasks are discussed more generally.

The nine series of studies planned or in progress in the areas of information assimilation and decision making are:

I. Amount and density of information.

II. Specificity of information.

III. Alpha-numeric and symbolic presentation.

IV. Type, extent, and rate of information updating.

V. Coding of updated information and hard copy.

VI. Sequence of information presentation.

VII. Individual and group work methods and displays.

COMMAND INFORMATION PROCESSING SYSTEMS--A HUMAN FACTORS RESEARCH PROGRAM

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COMMAND INFORMATION PROCESSING SYSTEMS--A HUMAN FACTORS RESEARCH PROGRAM

The Army is developing Automated Data Systems within the Army in the Field (ADSAF) for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. The ADSAF concept includes a network of cross-linked highly automated computerized systems, each dealing with relatively specialized functions, and all feeding information to an automated tactical operations system (TOS). Since effective performance of these new systems depends ultimately on human components, the need for human factors information is paramount. The present report describes the scope, rationale, and organization of a research program to provide that information. The research is conducted by the COMMAND SYSTEMS Task of the U. S. Army Personnel Research Office.

OBJECTIVES OF THE RESEARCH PROGRAM

Task objectives are to maximize combat effectiveness of current and future command information processing systems by providing designers, developers, and users information concerning:

1. Objective performance measures for evaluation of system and subsystem effectiveness.

2. Effects of characteristics of the information presented--amount, density, type, coding, updating, etc.

3. Capabilities, limitations and reliability of human performance.

4. Various modes and sensory modalities of presenting information for assimilation and decision making.

5. Specification of effective individual and group work methods and techniques.

6. Allocation of functions among men and equipment.

7. Procedures for identification and assignment of appropriate personnel to critical positions.

8. Man-machine implications of alternative system configurations.

AUTOMATED TACTICAL OPERATIONS SYSTEMS

Major Activities

An automated tactical operations system (TOS) is a facility in which representatives of general and special staff sections are concerned with current tactical and tactical support operations. These representatives assist the commander in the tactical operations aspects of his exercise of command by providing current information on the tactical support available and intelligence estimates of enemy actions, by making recommendations for command decisions, and by issuing implementing instructions. Rapid coordination among operational staff elements is essential in view of the advent of nuclear weapons and increased capabilities for mobility.

The purpose of an automated TOS is to assist the staff in the receipt, processing, storage, display, and transmittal of information usually represented in maps, charts, journals, and work sheets. The TOS may perform certain computations on call--target analysis, fallout prediction, and troop movements--using input, storage, computing, display, and communications devices. Automation will enable the center to provide information of greater scope, depth, and timeliness and will allow more time for consideration and use of this information in decision making. Some activities that will take place in a TOS are:

1. Continuous and simultaneous display and evaluation of available information required for decisions concerning tactical and tactical support operations.

2. Communication of tactical information and requirements to appropriate general staff sections, and transmission of instructions to tactical units and tactical support units or agencies.

3. Continuous transmission of situation information by each element in a TOS to the corresponding element in an alternate TOS.

Critical Information Processing Functions

An automated TOS will receive vast amounts of information from many and varied sources. The information varies widely in content, form, and degree of completeness. Further, the information often affects several different staff groups. The raw data require a great deal of handling and processing by man and equipment. Personnel will work under a wide variety of conditions ranging from situations that are relatively pressure-free to those that are over-whelmingly burdensome. Looking at the system as a whole, there appear to be five critical operations that man and equipment have to perform (Figure 1):

1. Screen incoming data for pertinence, credibility, impact, priority, and routing.

2. Transform the raw data for input into storage devices.

3. Input the transformed data into storage devices for subsequent computation and display (Figure 2, 3).

4. Assimilate data displayed (Figure 4).

5. Decide on courses of action based on information displayed and information from other sources.

Other operations that must be performed--computer programming, trouble shooting, and maintenance of equipment--have been deliberately excluded from the COMMAND SYSTEMS Task research program as not falling within the relatively homogenous domain of real-time processing of operational tactical information, the major focus of the program.

DELINEATING THE RESEARCH PROBLEMS

The major problems in and surrounding automated command information processing systems emerge from a lack of experience in the use of such systems. From an examination of Army, Navy, and Air Force reports and human factors research literature and from observation of equipment and systems in operation, a number of basic and critical questions were identified which have to be answered before such systems can be designed and used most effectively. These questions have implications for all five critical human information processing functions. The questions interact within each functional area and have an impact on the other areas as well. The particular grouping of questions is somewhat arbitrary, and other patterns may emerge after additional research is performed in these information processing systems.

Since automated command systems are designed to furnish information to the commander and his staff to assist them in the critical functions of information assimilation and decision making, current task activity centers about problem formulation and research in these two functions. These problems--and research studies designed to resolve them--are described in some detail. Questions are stated from the point of view of optimizing accuracy, appropriateness, and speed of information assimilation and decision making. Questions clustering about screening, input, transformation of information and system integration are subjects of a more general discussion presented later.

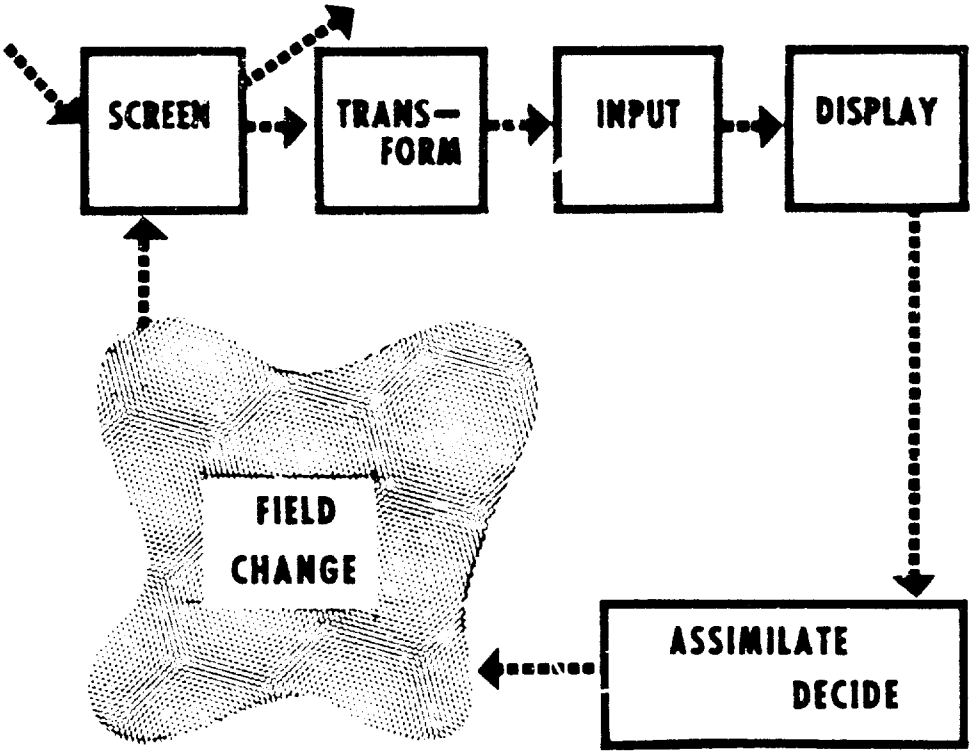

Figure 1. Schematic representation of operations and information flow in an automated TOS.

Figure 2. Example of symbolic data entry device.

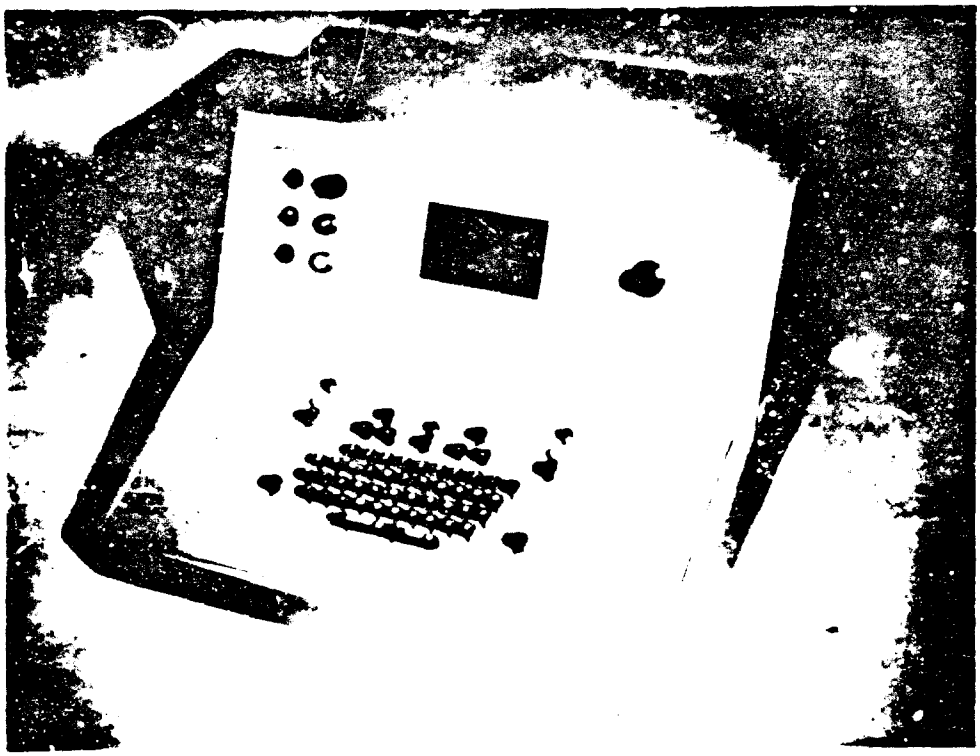

Figure 3. Example of alpha-numeric data entry device.

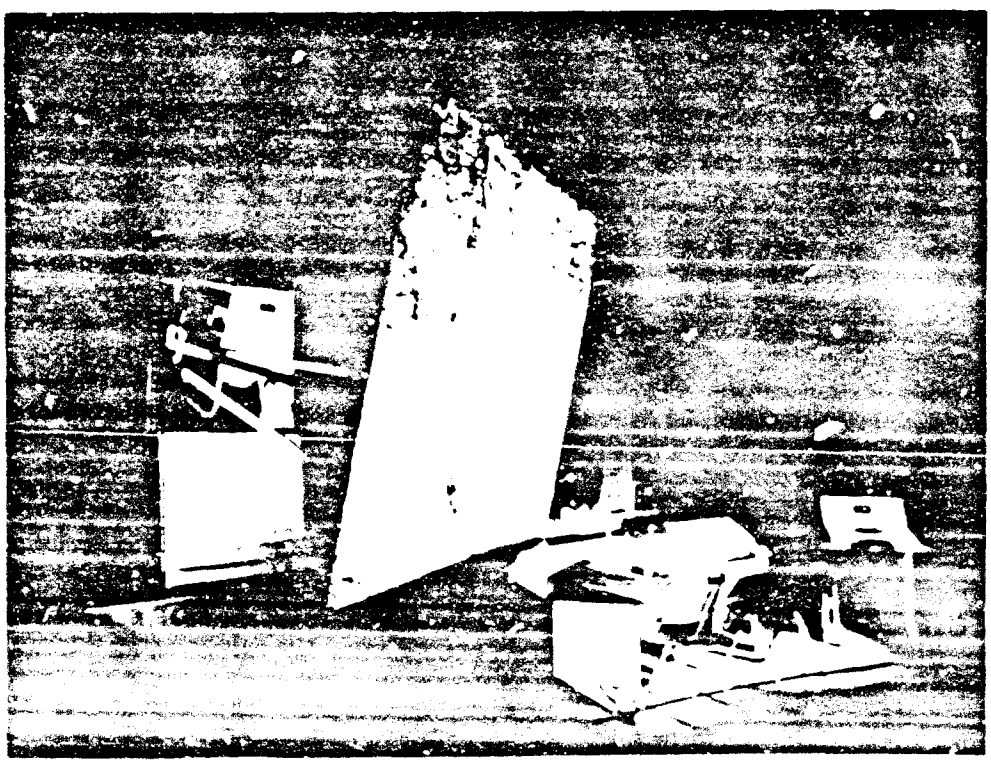

Figure 4. Example of group display.

Characteristics of Information Displayed

In this area, questions revolve around (1) the amount of information it is possible to absorb, integrate, and weigh effectively; (2) the density, format, and coding that are best for presentation and conspicuity of information; (3) the most appropriate combinations of specific information and general information to be included in the system; and (4) the relative effectiveness of alpha-numeric (totes) and symbolic (maps and overlays) display of different classes of information.

Dynamic Aspects of Information

Questions in a second category are concerned with the dynamic aspects of the information presented to commanders and their staffs. What combinations of rate of information updating and degree of change in an update are optimum for depicting changes that have occurred? What is the utility of coding updated information in transient displays to highlight changes in a situation? How useful is hard copy for comparing past information with current information? For pointing up trends and providing a sense of "history"? For manual backup and use in alternate TOC's? When information is available at varying levels of specificity and in different scales, are certain sequences of viewing the information better than others?

Display Modes

What display or sensory modalities are best for information assimilation and decision making? Would certain combinations of sensory modalities enhance performance? What are the relative merits of group versus individual displays and work methods? Are both kinds necessary?

Computer-Aided Performance

Problems in a fourth category concern the use of a computer as an aid in generating quantitative estimates of the probability of events, decision alternatives, and consequences. Research in this area seeks to extend the role of the computer and capitalize on its capabilities beyond its delimited use as a rapid and convenient device for driving displays and for information storage and retrieval.

RESEARCH APPROACH

The overall approach integrates several series of empirical studies through laboratory simulation of the five major information processing functions. By and large, these functions will first be studied separately

for better control and comprehension. Research findings will then be synthesized and applied in the integration of the five functions into alternative system configurations. Most of the research effort for the next several years will concentrate on the functions of information assimilation and decision-making unless circumstances and resources indicate a shift in emphasis or a broader effort.

The Command Systems Laboratory

To simulate certain aspects of TOS functions (operations, intelligence), a research laboratory was established. The following equipment has been acquired:

Two random access slide projectors (100-slide capacity each). The slide projectors allow for quick access to a variety of slides and use of overlay techniques for presenting information.

Large rear-view projection screen. This type of screen permits illumination of the work area, reducing the possibility of after-images without interfering with easy group viewing of the displayed material.

Three individual viewing consoles. Components of the AN/MSQ-19 (a prototype Automated Tactical Operations Center) became available. The COMMAND SYSTEMS Task acquired three individual consoles and accessory equipment for individual viewing of any kind of information--up to five slides per console simultaneously in full color, color coded, or black and white.

Five time-and-event recorders. These recorders were acquired in order to allow collection of group data and to provide a permanent record of time and response simultaneously.

Photographic station. The station contains a camera and processing equipment for the rapid photographing and slide generation of chart and map layouts (stimulus material). A printing and developing unit uses the master transparency to prepare 35-mm chips compatible with the random access capability of group and individual displays.

The laboratory is gradually being equipped with peripheral equipment and various communication devices. U. S. AFRO computer facilities are being made available to the Task.

STUDIES IN INFORMATION ASSIMILATION AND DECISION MAKING

Studies will be conducted using alpha-numeric and symbolic information. The criterion or performance measures will consist of one or more measures of accuracy, quality, time, and certitude. The studies will incorporate substantive military problems, quantitative and qualitative

Table 1

SUMMARY OF ESTIMATED MAN-YEARS FOR EACH PROJECT BY FISCAL YEAR

Series and Project	Priority	Fiscal Year 64	65	66	67	68	69	70	71	72	73	Total Man-Years
I. Amount and Density of Information	A											
Project 1		1										1
Project 2			1	1	1							3
II. Specificity of Information	B											
Project 1					1							1
Project 2						1	1					2
III. Alpha-Numeric and Symbolic Presentation	B											
Project 1					1							1
Project 2						1	1					2
IV. Type, Extent, and Rate of Information Updating	A											
Project 1		1	1									2
Project 2			1	1								2
V. Coding of Updated Information and Hard Copy	A											
Project 1		2										2
Project 2			1									1
Project 3				1								1
VI. Sequence of Information Presentation	C											
Project 1								1	1			2
Project 2										1	1	2
VII. Individual & Group Work Methods & Displays	B											
Project 1						1	1					2
Project 2								1	1			2
VIII. Visual and Auditory Displays	C											
Project 1								1	1			2
Project 2										1	1	2
IX. Computer-Aided Performance	A											
Project 1		1	1	2	2	2						8
Project 2							2	2	2	3	3	12
Total Man-Years		5	5	5	5	5	5	5	5	5	5	50

aspects of information, format variations, and conceptual levels of information, and will sample problem solving situations of different complexity levels ranging from slow to rapid changes of events.

Each project (Table 1) will require several separate studies for completion. The list is not considered exhaustive; results from these projects will indicate, on an empirical basis, how to proceed. Further, any one project may be conducted alone or in combination with others, whichever is most feasible. Priorities (A, B, C) represent planned project initiation dates--the first third, second third, and last third of a 10-year (50 man-year) research effort. The planned sequence is based upon need for certain findings that are prerequisite to further pursuit of the program as well as on feasibility in terms of Task resources.

SERIES I. AMOUNT AND DENSITY OF INFORMATION

	Project 1	Project 2
PRIORITY: A		
ESTIMATED MAN-YEARS:	1	3
ESTIMATED INITIATION DATE:	1963	1965
ESTIMATED COMPLETION DATE:	1964	1967

Statement of the Problem

The amount and density of information it is possible to present to commanders and their staffs are immense in view of current and anticipated capabilities of storage, retrieval, and display devices. How much information of different kinds it is possible to absorb, integrate, and weigh effectively under different constraints of speed and accuracy is a question with important implications. These implications bear on the conceptualization of the kinds and amounts of information to be included in the system, the programming of the system, and, as a consequence, the design and development of the storage and retrieval aspects of the system. This series of studies will deal with the effect on performance of different amounts and densities of information to be presented.

Method of Attack

Project 1. Military information in the form of alpha-numeric Friendly Tactical Units Status totes and symbolic unit deployment overlays were presented to subjects. Total amounts of information and density were varied. Questions of different levels of complexity were asked of the subjects; alternative answers were distributed throughout the displays. Time taken to extract the answers and accuracy of response were analyzed as a function of the experimental variables. The results of these studies have been published.

Project 2. An optimum decision in a tactical situation is one in which the correct action is selected in the shortest possible time. Theoretically, the larger the amount of relevant information available to the decision maker, the greater are his chances of making the right decision. However, it will also take him longer to consider all the information available and make a decision. In this project, the interrelationship of speed and appropriateness or quality of decisions will be examined as a function of amount of relevant, irrelevant, and redundant information presented. A number of problems will be developed for which several solutions or decisions of varying quality are possible. The amount of information available for solution of the problems will be varied. Speed and quality of the decisions will be analyzed as a function of amount of information presented.

Other Projects. Several experiments in other series will include varying amounts and densities of information so as to ascertain the interactive effects of other variables (coding, format, etc.) on the shape and slope of performance functions involving amount and density. The results may suggest techniques and methods for increasing the information handling and processing capabilities of humans.

Potential Research Payoff

1. Information on trade-off values of amount of information to be presented or considered, quality of performance, and speed of performance.

2. Information bearing on the storage and retrieval requirements of command systems.

SERIES II. SPECIFICITY OF INFORMATION

	Project 1	Project 2
PRIORITY: B		
ESTIMATED MAN-YEARS:	1	2
ESTIMATED INITIATION DATE:	1967	1968
ESTIMATED COMPLETION DATE:	1967	1969

Statement of the Problem

It is now possible to present in a single display large amounts of information in the form of detailed symbols, numbers, letters, and words concerning the status of situations. When specific information is required--the precise number of men available for a mission, for example--nothing but the number will suffice. However, under many circumstances,

a great deal of detail may actually impede the processes of information assimilation and decision making rather than enhance them. When different kinds of information have to be collated for integration and decision making purposes, a simpler and more gross data classification or grouping system may be most effective.

Method of Attack

Project 1. This project will examine the effects of variations in amount of detail and in techniques of grouping and simplifying the data presented on information assimilation and decision making from alpha-numeric data. Several levels of detail will be used to depict a changing situation. Individuals will be required to extract information, keep track of certain aspects of the situation, and make judgments about what is likely to happen (enemy preparing for attack, enemy readying to fire a missile, etc.). Performance will be analyzed as a function of the experimental variations introduced.

Project 2. In this project, several map and overlay scales and several levels of unit detail (battalion, regiment, and division) will be used to present military situations. Subjects will be required to resolve questions and problems of different levels of complexity and scope. Accuracy of answers, quality of decisions, time taken to respond will be analyzed in relation to the frequency, sequence, and duration of viewing the different scales and levels of detail.

Potential Research Payoff

1. Specification of the most appropriate levels of information detail necessary for effective information assimilation and decision making under various conditions.

2. Guidance to command system hardware designers and developers concerning desirable system storage capacities.

SERIES III. ALPHA-NUMERIC AND SYMBOLIC PRESENTATION

	Project 1	Project 2
PRIORITY: B		
ESTIMATED MAN-YEARS	1	2
ESTIMATED INITIATION DATE:	1967	1968
ESTIMATED COMPLETION DATE:	1967	1969

Statement of the Problem

Considering the mass of information involved in large-scale military operations, significant benefit could derive from knowledge about the relative merits of presenting information in alpha-numeric or symbolic form. In current and future systems, it is possible to present information in the form of tables, charts, graphs, maps, overlays, and highly abstract symbols. It may be conjectured that relational information tends to be more efficiently assimilated from symbolic presentations and that discrete information is more efficiently assimilated from alpha-numeric presentations. Choice of method could then depend on the nature of the information and the objective of the user. This series of studies will examine the kinds of information, tasks, and circumstances which indicate the use of one or another form of presentation or certain combinations.

Method of Attack

Project 1. Several situations will be depicted in alpha-numeric and symbolic form. Additional variations of different aspects of the information presented will be introduced--amount, kind (highly specific, general-relational), type of change, extent of change and rate of change. Subjects will be required to perform tasks involving extraction of information and memory. Time and accuracy measures will be analyzed as a function of the experimental variations of the information presented.

Project 2. Having ascertained the effects of the above-mentioned variables on the performance of extraction and memory tasks--tasks necessary for and part of more complex functions such as information integration and decision making--guidelines will be available for incorporation of these and other variables in research on the more complex performances of interest. Studies will then be conducted on information integration and decision making using the same or similar variables and the same methods of depicting the problem situations. Speed and quality of decisions will be examined.

Potential Research Payoff

1. Specification of conditions under which information processing performance is differentially enhanced by presenting information to commanders and their staffs in alpha-numeric and symbolic forms.

2. Recommendations concerning data presentation capabilities of the system.

SERIES IV. TYPE EXTENT, AND RATE OF INFORMATION UPDATING

	Project 1	Project 2
PRIORITY: A		
ESTIMATED MAN-YEARS:	2	2
ESTIMATED INITIATION DATE:	1964	1965
ESTIMATED COMPLETION DATE:	1965	1966

Statement of the Problem

Military operations cover a broad spectrum of activities and situation change. Command system information updating must reflect changes differing in type, extent, and rate. Information may be updated frequently (near real time), necessitating fewer changes and smaller changes per update, but more slides and input operations. In contrast, updating may be relatively infrequent, with more and larger changes per update but fewer slides and input operations. With near real-time updating, users of information may have difficulty following the frequent changes. On the other hand, infrequently updated information may have limited use because of gaps--the absence of steps showing how the present situation evolved from the past. Other system considerations such as slide generation, input equipment, and operations enter into this problem area. This series of studies will seek to provide answers to such questions as: What are the effects of variations in type, extent, and rate of information change and updating on information assimilation and decision making? What are the capabilities and limitations of human awareness and comprehension of what is going on under such different conditions?

Method of Attack

Project 1. Changing field situations will be depicted through a series of displays in which changes of varying type and extent have been introduced. Military units will be removed, added, repositioned; statements and figures regarding their status and that of other units will be modified. Subjects will be required to extract and memorize information, keep track of the ongoing situations, and render judgments on the basis of what is unfolding. Time and accuracy scores will be obtained for each subject's performance. The results of this project will provide some data on how persons handle information under changing conditions. These data will also be useful in suggesting what to incorporate in more complicated research projects.

Project 2. Situations similar to those used in the previous project will be depicted here except that variations in rate of change and time allowed for viewing the information will be introduced. In addition, the technique of time compression motion pictures will be tried

out as a means of enhancing the grasp of a situation that is changing minutely and at an extremely slow rate. Tasks and performance measures similar to those developed for Project 1 will be used.

Potential Research Payoff

1. Techniques for mitigating or eliminating negative impact of information change on human information processing performance in on-going situations.

2. Information on required updating capabilities for system developers.

SERIES V. CODING OF UPDATED INFORMATION AND HARD COPY

	Project 1	Project 2	Project 3
PRIORITY: A			
ESTIMATED MAN-YEARS:	2	1	1
ESTIMATED INITIATION DATE:	1964	1965	1966
ESTIMATED COMPLETION DATE:	1965	1966	1966

Statement of the Problem

As situations change, new information becomes available to a Command System. Additions, changes, and deletions must be entered into the system for information updating. It may be highly critical that the command staff become aware of these changes, however small. Two ways of assisting the staff in this connection are (1) making available copy of past situations to compare with the present situations, and (2) coding updated information so that the past situation and the present situation are available on one slide. Increases in awareness of a changing situation should provide a better sense of history and trends and thereby more useful information to enter into the decision process. This series of studies will deal with ways of presenting information and changes in order to make them more conspicuous and more easily assimilated.

Methods of Attack

Project 1. The purpose of this project is to ascertain the effects of uncoded information and hard copy and several different kinds of information coding (size, brightness, etc.) on information assimilation and decision making. Subjects will be presented with series of uncoded and coded alpha-numeric and symbolic displays in which changes of

different type and extent have occurred, corresponding to changing events in the real world. They will be asked specific questions regarding the content and changes in content of the displays, trends in the ongoing situation, and conclusions they have reached. Measures of speed, accuracy, quality, and completeness of responses will be taken and analyzed.

Project 2. If coding of information is found to make a significant contribution to performance, the relative merits of extended coding will be explored. Changes differing in type and extent, significant events, history, will be differentially coded for presentation to the viewers of displays. Performance will be analyzed to arrive at the merits and limits of coding to determine whether extended coding makes changing information more conspicuous more assimilable, and more readily used in the decision process.

Project 3. A related set of studies concerns the format used for information presentation. What is the best format for depicting different classes of information--vertical-horizontal matrices or circular layouts? What types of format are most amenable to rapid updating? A number of different types of format will be tried out for presentation of information. In addition, simple annotation of information in narrative form will be tested against formatting which is usually more elaborate and less flexible.

Potential Research Payoff

1. Findings concerning ways of presenting information for maximum use by operational personnel in dynamically changing real-time situations.

2. Information for designers and developers on system capabilities (codes, hard copy, format) which may be desirable or necessary.

SERIES VI. SEQUENCE OF INFORMATION PRESENTATION

	Project 1	Project 2
PRIORITY: C		
ESTIMATED MAN-YEARS:	2	2
ESTIMATED INITIATION DATE:	1970	1972
ESTIMATED COMPLETION DATE:	1971	1973

Statement of the Problem

Automated command information processing systems will contain information of different levels of specificity or detail in the form of alphanumeric charts and map and overlay scales. Individual users of these systems, when left to their own devices, will vary in the order in which they go through and consider charts and scales of different levels of specificity in the solution of problems. Examples from research testify to the inadequacy of work methods arrived at through "natural inclination". This series of studies will attempt to shed some light on the following kinds of questions: Should the sequence of information presentation be determined or should the user be able to interrupt the sequence and establish his own? Quite apart from sequence through different levels of information specificity, should users trigger the system for important information or should the system alert the users when important information is received? Is human interruption likely to cause important information to be suppressed in a developing sequence of information depicting events in the real world? In short, how active a role should the information user play in these systems and under what circumstances?

Method of Attack

Project 1. In this project, studies will be conducted on the simpler tasks of information extraction and assimilation. Situations will be depicted with information of different levels of specificity. Events of varying importance will be built into the situations. Experimental sequences of information presentation will be developed and tested against sequences preferred by individuals and groups. Accuracy and speed of information acquisition and assimilation will be compared for the different sequences.

Project 2. It may be hypothesized that users should play a more active role with relatively simple tasks under no serious time constraints and having no serious consequences and a more passive role with more complex tasks under severe time constraints and having the potential for major impact. Project 1 deals with the simpler tasks. Studies under Project 2 deal with the more complex tasks. Situations and variables similar to those in Project 1 will be used here. The performance of interest, however, will be speed and quality of judgments and decisions.

Potential Research Payoff

1. Problem solving methods for users of information in command systems.

2. Desirable computer and information presentation capabilities for designers of systems.

SERIES VII. INDIVIDUAL AND GROUP WORK METHODS AND DISPLAYS

	Project 1	Project 2
PRIORITY: B		
ESTIMATED MAN-YEARS:	2	2
ESTIMATED INITIATION DATE:	1968	1970
ESTIMATED COMPLETION DATE:	1969	1971

Statement of the Problem

When a group of individuals, each with different major responsibilities, are jointly involved in the solution of complex problems and arriving at major decisions, can they work more effectively when considering the same information simultaneously from one large group display or several individual displays? Or is it better for them to view whatever each feels is most relevant on his own individual display? Should each arrive at independent decisions and then pool them or should the ultimate decision be made jointly through give and take? One large display may provide the opportunity for rapid and mutually enhanced communication and thought processes. However, a number of smaller individual displays adds flexibility in that all specialists can view independently and simultaneously those information facets most relevant to their special interest. They can then gather to view the large display and take advantage of rapid and personal interaction and communication to resolve the issues before them. There are many more combinations and permutations that can be proposed. Studies in this area will seek to test the validity and utility of various procedures. The relative effectiveness of group, individual, and combined work methods and displays will be evaluated in a number of problem solving situations.

Method of Attack

Project 1. Studies under this project will deal with individual and group displays and work methods for extraction and assimilation of highly specific information such as may be found in alpha-numeric and symbolic displays. These studies will serve to identify the most promising work methods and displays. The results may also provide guidelines for research on the more complex task of decision making. Accuracy and completeness of information and time scores will be compared in terms of the experimental variables.

Project 2. Similar displays and work methods will be used with tasks requiring judgments and decisions based on more general relational information such as may be found in symbolic displays depicting the deployment of forces. It may be that in this situation, group displays

and work methods are indicated, whereas in the situation requiring specific information the group display could result in unnecessary delay for other users waiting their turn for information specific to their needs. In this project, measures of speed and quality of performance will be compared across work methods and displays.

Potential Research Payoff

1. Recommendations concerning individual and group work methods for different kinds of tasks to be performed by users of information.

2. Guidance to systems designers regarding the incorporation of individual and group displays.

SERIES VIII. VISUAL AND AUDITORY DISPLAYS

	Project 1	Project 2
PRIORITY: C		
ESTIMATED MAN-YEARS:	2	2
ESTIMATED INITIATION DATE:	1970	1972
ESTIMATED COMPLETION DATE:	1971	1973

Statement of the Problem

Only visual and auditory media are used for information transfer in automated command information processing systems. Because of certain limitations of the auditory sense--fewer dimensions for coding, attention demands, sequential arrival of information, rate of information transmission limited to speaking rate-- more and more emphasis appears to have been placed on visual displays. It seems reasonable to question whether visual channels are overloaded, and whether auditory channels are being sufficiently utilized. Some of the very limitations of the auditory sense may possibly be exploited. If the information is simple, if there are frequent and prolonged periods of quiescence, if some classes of information are better assimilated and utilized when presented in a particular sequence, auditory channels might be preferable. The following studies will address themselves to some of these questions.

Method of Attack

Project 1. Examples of studies in this area are a comparison of the relative merits of the two media for various classes of information, and the effect of different allocations of information transmission load to sensory media. Here again, the level of information specificity may

play an important role. For example, the auditory sense may be perfectly adequate for highly specific concrete information in the form of particular letters, words, or numbers and thereby make it possible to lessen the load on the visual sense. Conversely, it may be desirable to reserve visual channels for the perusal and consideration of more general relational information.

The studies, therefore, will be concerned with the presentation of the same kinds of information to the two senses and varying allocations of different kinds of information to the two senses. Accuracy, completeness, and speed of performance will be analyzed as a function of the experimental manipulations.

Project 2. A related but somewhat separate area of endeavor is the exploitation of the simultaneous use of different senses. Multiple channels operating simultaneously may be found to be particularly effective in alerting users to important aspects of information, in reinforcing the acquisition and retention of particular facts and relations. This approach may be necessary if the amount of visual coding of information that is possible reaches its limits rather quickly. These concepts will be tested in several situations ranging in degree of task complexity. Single and simultaneous-multiple channels will be compared in their effects on performance.

Potential Research Payoff

1. Guidance to command system designers and developers concerning communication channel capability, allocation, and integration.

2. Work methods and techniques for improving information conspicuity, transmission, and retention.

SERIES IX. COMPUTER-AIDED PERFORMANCE

	Project 1	Project 2
PRIORITY: A		
ESTIMATED MAN-YEARS:	8	12
ESTIMATED INITIATION DATE:	1964	1969
ESTIMATED COMPLETION DATE:	1968	1973

Statement of the Problem

This area places major emphasis on the use of the computer as an aid to man in information assimilation and decision making rather than merely as a rapid and convenient information storage and retrieval device.

It is envisaged that the computer can perform at least two very significant functions: (1) compute and furnish useful credibility and probability data about the operational information, thereby assisting the command staff to wade through vast amounts of information, enhancing the comprehension and grasp of a complex situation, and providing assistance in the weighting and tradeoff process that must occur when many factors must be considered; (2) integrate and synthesize a number of lower order decisions into one or more ultimate decisions with estimates of consequences.

Method of Attack

Project 1. A series of studies will be conducted in which military situations and information will be depicted without and with accompanying data on credibility or sources of information (enemy prisoner, photograph) and/or probability of various events (p = .7 that the enemy missile is being readied to fire) and without such auxiliary information. Further, the form and content of these accompanying data will be varied. Problems and questions of varied complexity will be presented to the subjects. Performance will be analyzed to ascertain the degree to which such data improve information assimilation and decision making.

Project 2. Studies under this project will deal with the development and validation of models for arriving at decisions through the simultaneous consideration of many factors and through the initial fractionation of the problem into sub-problems and the synthesis of sub-decisions into more ultimate decisions. Much of this work will be done through the use of computer simulation to sort out the most promising approaches. Studies will follow in which a computer will serve as an aid to the persons who have the responsibilities for making decisions in man-computer systems. Decision speed and quality will be analyzed as a function of the different models and techniques introduced.

Potential Research Payoff

1. Improved methods for extraction, assimilation, and retention of information by operational personnel.

2. Improved speed and quality of decisions.

3. Information on computer and data presentation capabilities required for command information processing systems.

STUDIES IN INFORMATION PREPARATION

Inasmuch as the Task effort for the next few years will be concentrated on the functions of decision making and information assimilation

from displays, the present report deals only briefly with the screening, transforming, and input functions of the TOS. A more comprehensive and articulated statement of planned research on the information preparation functions will be prepared prior to implementation of research on those functions.

The experimental variables to be dealt with in research on the information preparation functions will overlap with those investigated in the studies outlined for information assimilation and decision making. The primary purpose will be to ascertain how human performance in decision making and information assimilation can best be served by preparation of the information. The probable impact on load, speed, and accuracy of information preparation of requirements arising out of research on decision making and information assimilation can best be seen in the context of the studies dealing with specificity, alpha-numeric and symbolic presentation of information, probability information in decision making, and type, extent, and rate of information updating. Findings in those areas can be expected to have an impact on information preparation functions with respect to number, type, and rate of separate inputs, data transformation, screening and sorting categories required.

By way of specific examples, the close interrelationships among the five human functional areas can be seen by tracing the implications of some findings throughout the five functions.

The input function is directly affected by the resolution of problems in the information assimilation and decision making areas. Conclusions concerning amount, density, specificity, content, and form of information to be presented to the commander and his staff will affect the load and demands on the input operators. For example, findings on the general effectiveness of alpha-numeric and symbolic displays may conflict with the efficiency with which information can be input though the corresponding input devices. While symbolic representation may be more useful in the decision making process, input of symbolic information may prove to be very costly in terms of time and accuracy, especially when different map and overlay scales have to be used. Other related questions must be answered concerning the types of device (keyboards, light pens, styluses) and input verification methods that are best for input and update functions.

When the implications of these factors are traced back to the transforming operation that precedes information input, additional considerations must be faced. Findings can be expected to influence the total amount of transforming that will have to be done, the proportion of different transformations (plain language to plain language, plain language to symbols), and the method of transforming (simple annotations such as underlining and circling versus highly formalized formats and templates).

In the information screening function, factors such as load, number, and types of sorting classes, routing, and the configuration of individuals for the effective handling of large masses of varied raw data emerge

from, and must be amalgamated with, all the questions discussed above. Amalgamation, synthesis, integration, and other total system concepts are the subject following this section.

STUDIES IN SYSTEM INTEGRATION

The previous sections of the present report dealt with questions and problems that interact within and across each of the critical real-time information processing functions or subsystems. Total system concepts were treated briefly by allusion or implication. Problems concerning the total system will be treated more explicitly.

Questions in the area of system integration fall into two major categories: integration of functions and subsystems within the TOS, and integration of the TOS within a larger framework or complex of major systems such as the ADSAF. In the first category, emphasis is placed on internal consistency and compatability. In the second, interfaces with other major systems and contributions to the goals of a higher order of system integration must receive major attention. Again, because of the nature of the interdependencies involved, questions in both categories of concern must be treated or regarded simultaneously to whatever extent possible.

Within TOS

Performance measures. Performance measures are needed at three levels: at the total system level, at the subsystem level, and at the level within a system or subsystem where individuals operate in critical positions. By measuring performance at these three levels simultaneously, the relationships among them can be ascertained. It may then be possible to predict the effects of changes in performance at one level on performance at other levels. Information on these relationships is necessary to avoid the pitfalls of suboptimization--a situation wherein performance is improved at the subsystem or individual level at the expense of total system performance.

To the maximum extent possible, the performance measures will be objective and quantified. They may be obtained from records that are routinely maintained or from forms devised specifically for these studies. In some cases, judgments by knowledgeable operational personnel will be used. The measures contemplated will vary in specificity and inclusiveness.

Relevant and objective performance measures are a basic requirement for all further research. The measures developed are expected to reflect the effects of variations in conditions or variables. Examination of such effects will make it possible to identify those factors which make

a significant contribution to the overall success or failure of the system. Additionally, such measures will be of use to commanders in assessing the capabilities of their system, subsystems, and individuals.

Manual backup system. Highly complex automated systems such as are contemplated are susceptible to breakdown. For obvious reasons, questions of system component redundancy and manual backup systems merit a great deal of attention. Under the assumption that profuse hardware redundancy may eliminate most of the down-time problems but that cost constraints will preclude such an approach, research in this area will focus on manual backup of automated systems. Since it will probably be impossible to duplicate in manual operations all the information and processing handled by a computerized system, a major objective will be to determine the elements that are essential and should be included in a manual backup system. Additional problems include the number and kinds of persons that are needed, their organization, methods and procedures to be used by them, and alternate channels and rules of communication. Studies will be conducted in which these and other factors will be manipulated in the context of system breakdown and switchover to manual backup system during problem solving and decision making tasks.

Allocation of functions to man and equipment. Based on numerous studies outlined earlier, considerable information will be available on the capabilities, limitations, and reliability of men and equipment. This area, therefore, will concern itself with the best blend of functional allocation among men and equipment. Research will attempt to show the relative effectiveness of various functional allocations for performance of the command systems mission. Implications of the findings will be in terms of capabilities that need to be incorporated into the system. For example, what should be automated and what manual? How complex and exotic should the hardware be? What special hardware aids are necessary? Is specialized training indicated?

System configuration. This area is related to the one just discussed in that it deals with the physical configuration of all the elements that make up the system. Physical considerations include the actual spatial layout and placement of men and equipment for best performance of the mission. Other problems such as rapid system set-up and close-down, mobility, and dispersion must be resolved for a quick-response field army system. It is planned that most of the research in this area will involve study of these problems through mockup and manipulation of models of equipment and people.

System procedures. Another related area concerns total system work methods, rules, procedures, communication channels, information flow, and coordination among staff elements. Focus is on the integration of a multitude of tasks, functions, and purposes into a smoothly running operation wherein several purposes must be served simultaneously so that all the resources possible may be brought to bear toward the ultimate objective. This area, as the previous area, has potential for many

combinations and permutations in arriving at an optimal solution. Consequently, it will be necessary to reduce the many possibilities through systems analysis to a feasible number that can be tested and evaluated.

Simulation. In many instances, it will be possible to test various total system problems, concepts, and approaches through analytical treatment of logical models and computer simulation. From some of the earlier studies, it will be possible to furnish some empirically based parametric values for use in the models. This whole procedure will then serve as a screening process for reducing the number of additional research studies to be conducted and will permit focusing and emphasis on the problems that merit the greatest effort. In order to minimize requirements for, and interference with, operational systems, laboratory-type simulation equipment and methods will also be used. On occasion, older systems or components may serve as simulators and vehicles for the study of more advanced systems. Ultimately, however, it will be necessary to do a substantial portion of research using operational systems and personnel in the field or at training centers. This is particularly important when it is not possible to simulate the systems with sufficient fidelity and when final testing and validation must be accomplished.

TOS-ADSAF Interface

As mentioned earlier, the TOS itself is part of a larger system complex within which there exist mutual interdependencies. Many of the questions raised at other levels throughout the program of research are also applicable at this level of conceptualization and discourse. Rather than trace each question through to this level, questions relatively specific to this level will be dealt with very briefly and in general terms.

For example, informational requirements and interdependencies have to be ascertained and ways devised to satisfy them. In the attempt, other questions will emerge. Should the various systems of the ADSAF feed and update information to each other automatically and periodically or should they do this upon request? Such a question has implications for the problems of centralization-decentralization of critical data bases. How much duplication and overlap should there be among the various systems? The question must be viewed in terms of the need for capability for independent operation and backup. These are but a few of the many problems that will arise in interfacing the several systems so that requirements of compatability, speed, accuracy, and smooth, uninterrupted functioning are met.

In carrying out this program of research, total system integration considerations and problems will provide a context within which the more specific studies will be accomplished. The final and most meaningful grappling with integration and synthesis must await the accumulation of hard facts concerning the elements, components, and subsystems that are to be integrated.

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13 ABSTRACT

The COMMAND SYSTEMS Task seeks to develop research information by which the effectiveness of current and future command information processing systems may be maximized, pursuing its objective through intensive experimentation in specific Army man-machine complexes. The present publication describes the scope, rationale, and organization of a research program to provide that information to designers, developers, and users. The program represents a comprehensive approach to research concerned with automated command information processing systems, ranging from detailed studies of discrete human functions to integration of sizable highly automated computerized systems. Task effort for the present and in the immediate future will be concentrated on studies dealing with information assimilation and decision making. The report delineates a series of studies in progress or projected on nine major aspects of these functions: 1) Amount and density of information; 2) Specificity of information; 3) Alpha-numeric and symbolic presentation; 4) Type, extent, and rate of information updating; 5) Coding of updated information and hard copy; 6) Sequence of information presentation; 7) Individual and group work methods and displays; 8) Visual and auditory displays; 9) Computer-aided performance. Research to be accomplished in remaining subtasks concerned with problems in the information preparation and system integration areas is more generally discussed.

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