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FINAL REPORT
DOD USER-NEEDS STUDY, PHASE II

FLOW OF SCIENTIFIC AND TECHNICAL INFORMATION WITHIN THE DEFENSE INDUSTRY

VOLUME I
OVERVIEW

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DOD USER-NEEDS STUDY, PHASE II

FLOW OF SCIENTIFIC AND TECHNICAL INFORMATION WITHIN THE DEFENSE INDUSTRY

VOLUME I
OVERVIEW

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FOREWORD

The Department of Defense (DOD) has conducted a two-phase study to determine how scientists and engineers in government and industrial research, development and production activities acquire information for performing work assignments on DOD programs. This study is referred to as the DOD User-Needs Study, Phase I and Phase II.

Objectives of the study are to develop (a) an understanding of the scientific and engineering process and its technical information needs, (b) implications for current and future DOD scientific and engineering information systems, and (c) information to guide administrative decisions on the scope of DOD scientific and technical information programs.

The Phase I study covered the information needs of DOD personnel engaged in research, development, test and evaluation (RDT&E) activities. Results of this study are contained in Reference 1.

Phase II investigated the nation's defense industry to determine its information needs, and the flow of scientific and technical information (flow process) inherent in satisfying those needs. It is based on a representative sample of 1500 individuals from 83 organizations in the defense industry.

The Phase II Final Report describes the results of Phase II, and compares them with those of Phase I. It is presented in three volumes. Volume I contains a non technical summary of Phase II, including guidelines for management decisions and recommendations for the future. Volume II describes the technical approach, findings and recommendations of the study. Volume III presents the reduced data, in the form of frequency distributions and models for relationships among elements of the flow process.

Phase II was performed by North American Aviation, Inc., under Contract DSA-7-16244, awarded by the Defense Supply Agency and funded by the Advanced Research Projects Agency. The study was administered by Mr. Walter M. Carlson, Director of Technical Information in the office of the Director of Defense Research and Engineering, and monitored by Mr. Howard B. Lawson of the Defense Documentation Center. Survey interviews were made possible by the cooperation of the National Security Industrial Association and the participating organizations listed in Appendix A.

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1. INTRODUCTION

1.1 PURPOSE AND OBJECTIVES OF PHASE II

The principal technical tasks of Department of Defense (DOD) contractors are research, development and production of weapons and their supporting systems. Their efforts involve searching for and using an enormous amount of scientific and technical information. This store of information is continually growing, accompanied by an increasing need for improving the process of acquiring it.

The problem in the design of information systems is to channel the required information to interested persons as efficiently as possible. The goal is to provide the right information to the right person, in the right form, at the right time. A first step in achieving this goal is to define the user's need and procedures for acquiring technical information.

The Office of the Director of Defense Research and Engineering has initiated a two-phase study of user needs to determine the information acquisition patterns within the defense community. A prior study (DOD User-Needs Study, Phase I) surveyed these patterns among a random sample of research, development, test and evaluation (RDT&E) personnel of the Department of Defense.

The aim of the present Phase II study is to perform a similar survey to learn how scientists and engineers in the defense industry gather scientific and technical information. Data were obtained by personal interviews with a representative sample of 1500 from a population of approximately 120,000 scientists, engineers and technical personnel. These personnel were employed by 73 companies, 8 research institutes and 2 universities that are defense contractors. Each interview dealt with a specific task recently completed by the user, and his experiences relating to the need for, search for, and acquisition of information required in performing the task. Data were also collected concerning the individual's use of formal technical information centers and services, and on his background, experience and work activity.

The major study objectives were to answer questions in the following areas:

- What are the educational, experience and job characteristics of the users of scientific and technical information in the defense industry?
- What is the nature of the scientific and technical tasks within the defense industry?
- What characteristics does the defense industry exhibit in its utilization of technical information centers and services?
- What characterizes the search and acquisition process in the defense industry?

- What are the significant factors within the flow of scientific and technical information (flow process) for the defense industry?

- What are the differences between DOD in-house and defense industry personnel and their needs and procedures for acquiring scientific and technical information?

The study concentrated on the information wanted and used to perform specific tasks. It was not concerned with "current-awareness" (i.e., "intentional browsing" that is not task-oriented) information which a person uses to maintain an awareness of the state of the art, to educate himself, to review previously known areas, and to stimulate his thinking.

Many investigations have been performed, and much has been written, concerning the flow of scientific and technical information. The tendency, however, has been to examine only small portions of the flow process, or to speculate about large portions of the flow process in vague generalities. Therefore, very little of a comprehensive, definitive and unifying nature actually has been said about the process. The DOD User-Needs Study is the first attempt to obtain data on a large portion of the flow process, and the Phase II analysis is the first attempt to draw definitive and unifying conclusions from these data. This, in turn, will provide the first comprehensive definition of the information requirements in today's complex array of scientific and technical endeavors.

1.2 THE ANALYTICAL APPROACH[1]

The analytical approach used in Phase II is described in general terms in Section 4 of this volume. It will suffice here to observe that, in addition to the compilation of frequency distributions for the answers to a question or a pair of questions, the qualitative data have been transformed into numerical form. This transformation is based on the arrangement of question responses into an informative order, and the association of a numerical value with each question response. Then models are specified for relationships that are suspected among elements of the flow process. Finally the models are estimated from the data by means of regression analysis, to reveal significant relationships and factors within the flow process.

Accomplishments of the approach include:

- An informative structure for viewing the flow process.

- A quantitative form for the data, to expedite their analysis.

- Models for significant relationships among elements of the flow process.

- Significant factors within the flow process.

- A basis for future investigations.

These accomplishments pervade the Final Report. They enable it to present comprehensive, definitive and unifying descriptions and conclusions regarding large portions of the flow process.

[1]This analysis is respectfully dedicated to the memory of Dr. Edith Jay, whose ideas serve as an inspiration to all of us. The great contribution which she always brought to a project was prevented by her untimely passing.

The approach is believed to be novel in the field of information science. Its employment and testing in Phase II have yielded results that are encouraging, and implications for the future that are provocative.

1.3 ORGANIZATION OF VOLUME I

This volume is organized so that the reader can get the essence of the study by reading Sections 1, 2 and 3. Sections 4 and 5 present complementary information which will help the reader understand the first three sections in a broader context. More detailed findings are contained in the Appendices.

Section 2 presents some conclusions in the form of guidelines for managers and others concerned with the DOD scientific and technical information systems. These guidelines, which represent the major implications of the study, will serve to guide management decisions on the direction and scope of the DOD Scientific and Technical Information Program, and the Technical Logistics Data and Information Program.

Section 3 contains recommendations for the future which are thought to be most useful in continuing the progress begun by the DOD User-Needs Study. These recommendations are of three types:

- Additional field experimentation regarding the flow process.
- A program for analysis and optimization of the flow process.[2]
- Refined analysis of the data from the Phase I and Phase II studies.

Section 4 describes in general terms the methodology used in preparation for, conduct of, and analysis of the survey. It also discusses the modification of the Interview Guide. Finally, Section 5 discusses the background for interpreting the study and its results, to ensure the proper use of this report.

Appendix A lists the organizations participating in Phase II. A comparison of the Phase I and Phase II studies is presented in Appendix B. The basic findings of the Phase II study are summarized in Appendix C. These findings are focused on the (a) search and acquisition process, (b) utilization of information centers and services, (c) scientific or technical task, (d) user of scientific and technical information, and (e) significant factors within the flow process.

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[2] The flow process is optimized when its effect upon the performance of a scientific or technical task is optimized.

2. CONCLUSIONS

The major conclusions of the study can be expressed in the form of guidelines for management decisions bearing on the direction and scope of DOD information programs. These guidelines are supported by the numerical findings which are summarized in Appendices B and C, especially those in Figure C-12, and presented in detail in Volume II. The two surveys produced a considerable mass of data concerning the scientific and technical process and its information needs. It is likely that additional analysis in depth may yield further information about the user's needs and the flow process that would permit refinements and additions to the present guidelines.

2.1 IMPORTANCE OF CERTAIN CATEGORIES[3] OF INFORMATION

Priority of effort should be assigned to information which is:

- In the development phase of the research, development and production cycle.
- Related to design and performance.
- In the engineering field.

The engineering subfields that are of greatest interest are electronics and electrical engineering, and aeronautics and space technology.

2.2 IMPORTANCE OF THE LOCAL WORK ENVIRONMENT AS A SOURCE FOR INFORMATION[4]

Eighty percent of the time, the Phase II users first searched for information within the local work environment. Therefore, information policies should recognize and seek to strengthen the utility of local sources of scientific and technical information. Specifically, more effort should be devoted to:

- Organized storage and active circulation to the local work environment of information which is informal or semiformal in composition.
- Tailoring for the local work environment the indexing, abstracting, organization and analysis of information, prior to its distribution.
- Selective and automatic dissemination to the local work environment of these tailored indexes, abstracts, and organized and analyzed information.

Partially organized and analyzed ("once-over-lightly") information is of questionable value, since it satisfies only a small percentage of information needs in task-oriented situations.

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3 The categories are defined in the introduction to Appendix B.

4 The "local work environment" extends only as far from the user as an internal company consultant, but not as far as the company Technical Information Center, which is his connection with the formal information system (see Table 4-2).

2.3 PUBLICITY CONCERNING DOD INFORMATION CENTERS AND SERVICES

More effort should be devoted to publicity programs for informing the scientific and technical community, especially within the defense industry, regarding the availability of DOD Information Centers and Services and the procedures for their most efficient use.

2.4 SATISFYING THE NEEDS OF THE SIGNIFICANT USERS OF INFORMATION

More effort should be devoted to satisfying the needs, and minimizing the information acquisition problems, of the significant users of scientific and technical information. In general, these users are characterized by their value to the company: that is, they are research and development scientists or engineers who have an advanced degree, are specialists or in lower management levels, and are highly paid. These personnel are also the real users of information centers and services and the ones most frustrated by problems involving their use.

2.5 INPUT/OUTPUT RELATIONS FOR THE FLOW PROCESS

The major components of the flow process are the (a) USER of scientific and technical information, (b) scientific or technical TASK, (c) UTILIZATION of information centers and services, and (d) SEARCH AND ACQUISITION process. From a systems design point of view, it is informative to consider (see Figure 2-1):

- The primary "input/output" relation (symbolized by arrow 1) with USER and TASK as "inputs" (i.e., tending to influence) and UTILIZATION and SEARCH AND ACQUISITION as "outputs" (i.e., tending to be influenced).
- A secondary input/output relation (symbolized by arrow 2) with USER as input and TASK as output.
- A secondary input/output relation (symbolized by arrow 3) with USER as input and UTILIZATION as output.
- A secondary input/output relation (symbolized by the arrows marked 4) with USER, TASK and UTILIZATION as inputs and SEARCH AND ACQUISITION as output.

2.6 SIGNIFICANT RELATIONSHIPS WITHIN THE FLOW PROCESS

The analysis characterized relationships among elements of the flow process. These relationships should be utilized in the planning and operation of scientific and technical information programs. Among the more significant relationships are:

- The higher the user's level and value to his organization, the more complex the task and its information requirements.
- Greater complexity of the task occurs earlier in the research, development and production cycle. In the earlier phases of the cycle, information is needed in greater formality and detail; and it takes longer to acquire this information.

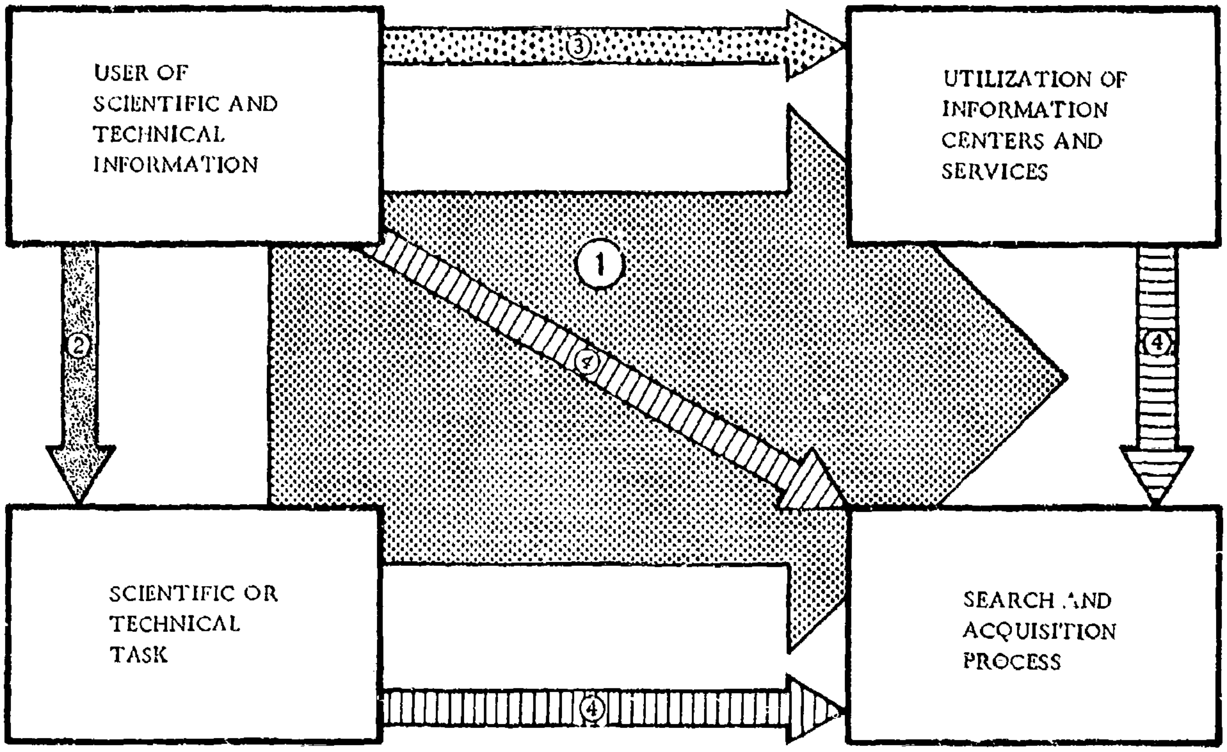

Figure 2-1. Input/Output Relations for the Flow Process

- As the formality of the task output increases (i.e., from findings through decisions to plans), the complexity of the information tends to increase.

- When more time is available for a task and for the acquisition of information, the user tends to be more demanding in regard to the organization of the media conveying the information and the volume of information required.

- Those who tend to make more use of information centers and services, want more formality and detail in the information media to satisfy their needs.

- When the user goes to a more distant first source (e.g., formal information centers) the information requested will involve more formal media, in greater volume and accompanied by a greater allowable acquisition time. On the other hand the more distant first source tends to yield only part of the needed information, so that further search is required.

2.7 COMPARISON OF PHASES I AND II

The five general conclusions of Phase I are:

- Engineering data is the most important category of information.
- The local work environment is the most important first source for information.
- Information analysis prior to distribution is important in a scientific and technical information program.
- The DOD Information Centers and Services are not sufficiently used.
- The user is not completely satisfied with his ability to obtain information.

Although answers to comparable questions in Phases I and II exhibit significant differences (see Appendix B), the Phase II data sustain these conclusions (see Sections 2.1 through 2.4).

2.8 CONTINUING STUDY AND ANALYSIS

More effort should be devoted to the extension of progress made by the DOD User-Needs Study, as described in the following section.

3. RECOMMENDATIONS

The two surveys of user needs within the Government and defense industry environments have yielded a wealth of valuable data relating to the scientific and technical information flow process. The analysis of these data, notwithstanding cost and schedule limitations inherent in an exploratory research project, has resulted in useful but preliminary insights into and explanations of the flow process. However, there are abundant lodes of information yet to be discovered, mined and refined, in order to exploit more fully the economic value of the available data base.[5]

The Phase II study was a pioneering attempt to draw comprehensive, definitive and unifying conclusions from data on a large portion of the flow process. From the perspective gained in this study, it is clear that certain portions of the flow process merit further investigation and that there is considerable room for refinement and extension of the analysis. A more detailed discussion of the recommendations contained here will be found in Volume II.

The present study has provided a valuable basis for this further investigation and refinement. In addition to yielding guidelines for management decisions, it has also provided:

- A structure and its numerical description with which to view, specify and estimate models describing the information flow process.
- A framework for designing field experiments, performing estimation and testing hypotheses concerning the flow process.
- A methodology for overcoming the analytic deficiencies in past and present user needs studies[6] by the development of a structure, accomplishment of its numerical description, and specification and estimation of multivariate models describing the flow process.
- A basis for the recommendations which follow concerning (a) additional field experimentation regarding the flow process; (b) a program for coordinating additional field experimentation and computer simulation in the analysis and optimization of the flow process (as previously noted, the flow process is optimized when its effect upon the performance of the scientific and technical tasks is optimized); and (c) refined analysis of the data from the Phase I and Phase II studies.

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[5]Since the discovery and exploitation of this information content is subject to the law of diminishing returns, the recommendations in the entire section are goals and should be assigned priorities according to the twin criteria of objectives and available resources.

[6]Noted by H. Menzel in Chapter 3 of Reference 2, and by B. Griffith and W. Paisley during the Progress Review Panel on Information Needs and Uses at the 29th Annual Meeting of the American Documentation Institute, October 3-7, 1966.

3.1 ADDITIONAL FIELD EXPERIMENTATION

In order that the implications of Phase II be fully exploited, the flow process merits further investigation. There should be additional field observation, experimentation and analysis regarding the flow process, such as:

- An investigation of the feasibility and effect upon the flow process of the guidelines in Section 2.
- An investigation of task-oriented use of information centers and services.
- Experiments, suggested in Reference 3, concerning (a) dissemination of documents; (b) dissemination of scientific and technical intelligence information (i.e., what is going on); (c) organization and analysis of information in selected fields; (d) indexes, title listings, abstracts and catalogues in selected fields; (e) Specialized Technical Information Centers; (f) techniques for processing information; and (g) evaluation and improvement of technical writing.
- Specific experiments suggested by refined analysis of the data (see Section 3.3).

3.2 A PROGRAM FOR ANALYSIS AND OPTIMIZATION

The flow of scientific and technical information has a profound, but as yet uncharacterized, effect upon the performance of scientific and technical tasks. In their efforts to improve task performance, both DOD and its contractors have made large investments in information centers and services. Optimization of the flow process will produce substantial benefits in terms of quality, resources and time.

The flow process and its effect upon task performance are quite complex, and field experimentation regarding them is both difficult and expensive. For such processes, mathematical solution is usually not feasible and computer simulation is often an effective and efficient means to complement field experimentation.

When the model (mathematical representation) for the process is translated into a simulation computer program (computer representation) for the process, the process and the effects of various factors upon it may be simulated. The accuracy and precision of the computer simulation increase as the accuracy and precision of the model increase. Therefore, computer simulation yields appropriate results at any stage of one's knowledge about a process, ranging from relative ignorance to relative certainty.

Specific recommendations for additional experimentation have already been given. We now briefly describe a general program to coordinate field experimentation and computer simulation in the analysis and optimization of the flow process. This program (see Figure 3-1) is an improvement of one which was developed by North American Aviation, Inc., and is currently being utilized by a Government Agency on a process of comparable complexity. A more complete treatment of the program will be found in Volume II.

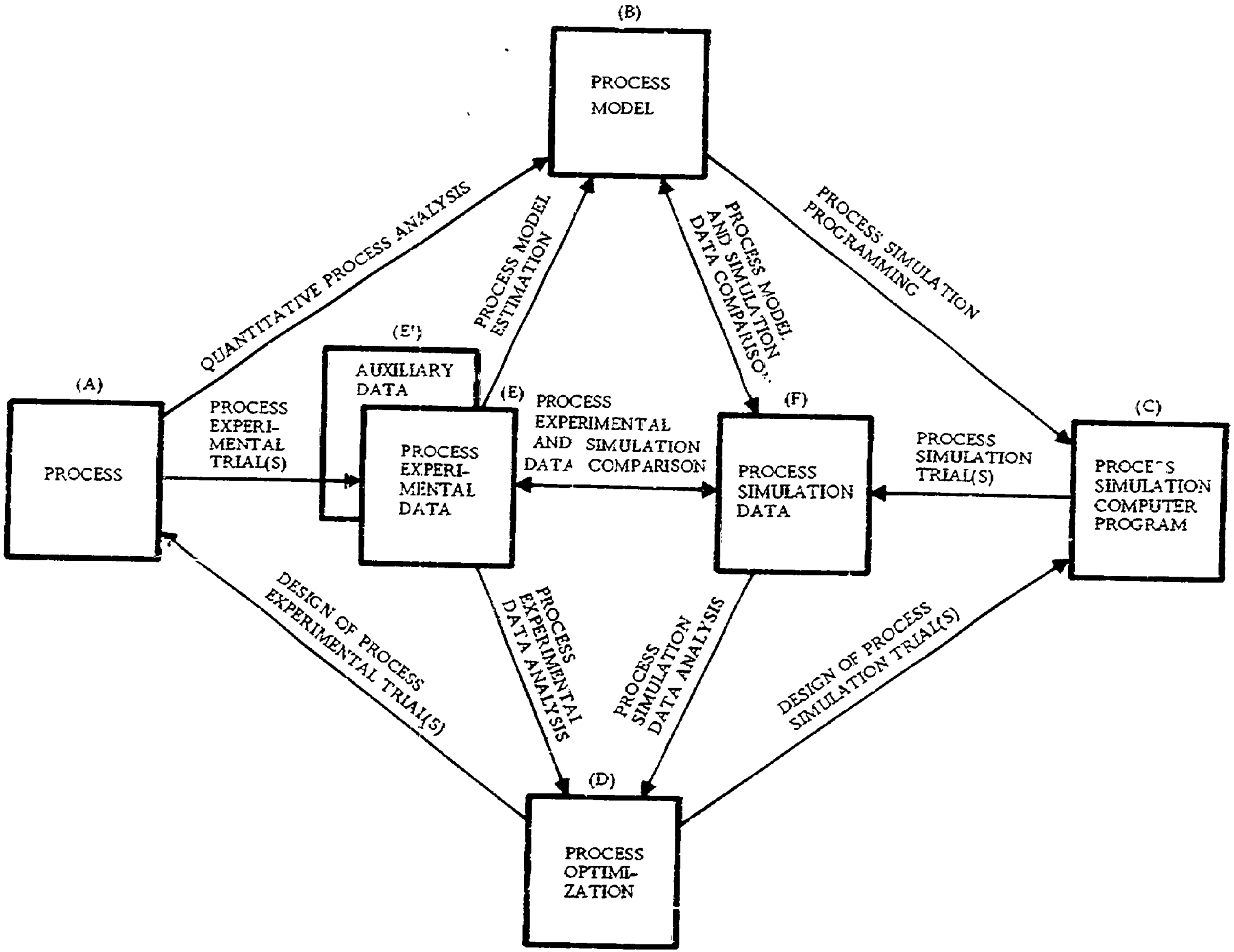

Figure 3-1. Program for Analysis and Optimization

The program, which is adaptive in nature, is composed of ten basic stages:

1. Quantitative process analysis to arrange the elements of the process into an informative order; associate a numerical value with each element; and formulate the general form of a process model, for relationships among the process elements, with unspecified constants.

2. Process (field) experimental trial(s) to yield process experimental data.

3. Process model estimation to produce estimates of unspecified constants in the general form of the process model from process experimental data and auxiliary data, when available.

4. Process simulation programming to construct a process simulation computer program from the process model.

5. Process simulation trial(s) to yield process simulation data.

6. Process model and simulation data comparison to provide a validation (i.e., positive check) for the process simulation computer program.

7. Process experimental and simulation data comparison to provide a validation for the combination of process model and simulation computer program.

8. Process experimental and simulation data analysis to aid process optimization by suggesting improvement of the process.

9. Process optimization to iteratively improve the process and apply appropriate stages of the program to the improved process.

10. Design of process experimental and simulation trials to implement process optimization.

Additional experimentation is covered by Stages 1 through 3. Stages 4 through 7 concern computer simulation and its validation. In Stages 8 through 10, analysis and optimization of the flow process are treated.

The recommendations stated here provide the basis and framework for a long-term investigation and improvement of the flow process.

3.3 REFINED ANALYSIS OF THE DATA

Since only a small fraction of the effort expended in collecting data is typically devoted to its analysis, a large amount of the information it contains generally is undiscovered and unexploited.

A more profound understanding of the DOD/defense industry information flow process can be achieved through more refined analysis of the data, as suggested below:

- More thorough examination of the distribution of answers to questions and their relationships.
- Investigation into the effect of company size, industry and interviewer bias on the answers to questions.
- Improvement in the arrangement of responses to a question, and the association of a numerical value with each response to a question.
- Reformulation and re-estimation of appropriate models in order to reflect the above improvements, and to investigate more specific relationships which involve only single questions (rather than combinations of related questions).
- For purposes such as the study of the selective dissemination process, formulation of reverse models to study the flow process in reverse (i.e., reverse the input/output relations described in Section 2.5 and Appendix C). An example would be a model relating the user's highest degree to the class of information, desired composition and layout of the conveying media, the first source for the information, and the usefulness of title listings and abstracts.
- Formulation and estimation of additional models describing the flow process, and utilization of additional analytical techniques (such as factor analysis).
- Division of the sample of 1500 users into appropriate subsamples to permit analysis and comparison of special groups, such as the three groups that acquired information that is (a) conceptual, (b) design and performance, and (c) production.
- Application, as appropriate, of the above suggestions in making further analyses of the Phase I data, the similarities and differences of the Phase I and Phase II data, and the combined data from Phase I and Phase II.

4. METHODOLOGY

The methodology employed in the study of the defense industry (Phase II) was based on precedents established in the prior Phase I study of DOD personnel engaged in RDT&E. Improvements in methodology were achieved by profiting from lessons learned in the Phase I study, and through the use of a more comprehensive and powerful analytical approach. Also, the Interview Guide used in Phase I was tailored and improved to make it more suitable for use in a survey of defense industry needs.

4.1 PREPARATION FOR INTERVIEWS

The initial portion of the study required (a) modification of the Interview Guide, (b) preparation of an Interview Guide Handbook and Reference Manual for use by the interviewers, (c) testing of the modified Interview Guide to validate revisions and provide a basis for further improvements, and (d) selection and training of the interviewers.

Modification of Interview Guide

The Phase I Interview Guide had to be modified in two major areas: (a) tailoring to the defense industry population; and (b) overall improvement based on Phase I experience, North American Aviation technical evaluation, and the pilot test. Modifications were designed to:

- Reorganize it, by removing extensive tables and including them in a separate Interview Reference Manual.
- Improve the printing and layout, making it easier to record data during interviews.
- Provide increased logical order of questions.
- Minimize the number of questions (e.g., by letting one group of related questions cover an entire subject, when possible).
- Assess the utilization of company Technical Information Centers.
- Assess the utilization of Non-DOD Specialized Information Centers.
- Investigate restrictions on availability of technical information.
- Provide for mutally exclusive responses.
- Expand, reorient and rearrange question responses.

The revised Interview Guide contained 63 questions, grouped according to (a) the user of information, (b) his most recent scientific or technical task, (c) his utilization of information centers and services, and (d) his search for and acquisition of information specifically related to the task. Most of the responses to questions in the Interview Guide are qualitative and, therefore, not susceptible to quantitative interpretation without using special techniques.

Interview Guide Handbook and Interview Reference Manual

The Interview Guide Handbook (Reference 4) is the basic documentation for the initial portion of the Phase II study. It contains an explanation of and instruction in the interviewing methods, questions to be covered and aids for the interviewers. In developing this Handbook, the primary theme was to tailor it to serve both as a training document on the objectives and conduct of the study and as an interviewer reference. The Handbook also contains the basic study correspondence, a directory of participating organizations and a glossary of terms.

An innovation in Phase II was the introduction of an Interview Reference Manual. This Manual contains a compact, easily-handled listing of frequently used and complex responses for questions in the Interview Guide. The document was basically an interviewer aid, and was shown to the respondent when it would facilitate the interview. Instructions in the use of the Interview Reference Manual are contained in the Interview Guide Handbook.

Pilot Test

A modified Interview Guide was pilot tested to validate the revisions accomplished for the Phase II study. As specified by DOD, the pilot testing was based on 20 interviews with selected engineering and scientific personnel of North American Aviation, Inc. The pilot test resulted in a reorganization of the questions into a more logical sequence.

Selection and Training of Interviewers

Interviewers were selected on the basis of their scientific and technical backgrounds, research experience, interviewing and survey experience, maturity, personality and responsibility. All interviewers had at least a bachelor's degree and prior interviewing experience. The interviewing staff employed in the Phase II survey included eight behavioral scientists, three operations research analysts and three information processing specialists.

Each interviewer was given a two-week training program, consisting of classroom instruction and controlled field practice interviews. Training emphasized standardization of survey interview techniques in dealing with a highly diversified sample. Training sessions included Program Orientation, Scientific and Technical Information Systems, Survey Operations, Review of Phase I Results, Comprehensive Study of the Interview Guide, Summary of the Analysis Plan, Interview Demonstration, and four days of practice interviews with critiques of student performance. Remedial sessions were scheduled when the need for them was indicated during the practice interviews.

Selection of Sample for the Interviews

The National Security Industrial Association and the Director of Technical Information in the Office of the Director of Defense Research and Engineering contacted and obtained voluntary participation of the majority of organizations cooperating in the survey. North American Aviation, Inc. helped arrange for the participation of additional qualifying organizations. The organizations surveyed included 14 of the top 25 DOD contractors and 17 of the top 25 RDT&E contractors. They are considered representative of the major DOD/RDT&E contractors. Appendix A lists participating organizations with the sample sizes drawn from each.

The Director of Technical Information provided explicit instructions on the method to be employed by the participating organizations in selecting the samples of individuals for interview. The sample for interview was obtained by the selection of a representative group of 1500 from a population of approximately 120,000 scientists, engineers and technical personnel. These personnel were employed by 73 companies, 8 research institutes and 2 universities having defense contracts. In addition, the sequential acquisition of data permitted strong positive checks to be made upon the internal consistency and representative nature of the sample. The individuals sampled represent approximately 1.5 percent of the total scientific, engineering and technical personnel of the 83 participating organizations.

Pre-Survey Preparation of the Interviewees

Early in the planning of survey operations, it was determined that the conduct of the survey and the quality of responses would be enhanced considerably if interviewees were familiar with the purpose of the study and the kinds of questions to be asked. Consequently a descriptive brochure, Synopsis of Interview Topics (an Appendix to Volume II), was developed and distributed to each interviewee in advance of the interview.

This brochure acquainted the interviewees with the topics to be discussed. It provided a frame of reference, introduced the general subject matter of the interview, and tended to ease possible confusion and apprehension. The Synopsis also reassured the interviewee's management that the survey was solely intended to investigate information needs and acquisition procedures, and that it was not an attempt to obtain classified or proprietary information. Comment from the interview staff indicated that the Synopsis fulfilled its intended purposes.

Interview Policy

The sample to be interviewed spanned a diversity of backgrounds (e.g., field of training and extent of formal education) and position levels (e.g., type of activity and level of responsibility). In addition, the flow of scientific and technical information is not widely discussed or understood. It was, therefore, realized that the interview questions might have different meanings to different interviewees.

In order to achieve comparable results under these conditions, the interview was "standardized" so that essentially the same information would be collected from each interviewee. This was achieved by the interviewer tailoring the formulation and sequence of the questions to each interviewee (i.e., "non-scheduled" interviewing). The interview was predominantly one of "free response," (i.e., where an explanation or description was required) in which there were few explicit bounds upon interviewee responses. An interviewer also encouraged interviewees to talk freely of their experiences, and to give examples of their information search and acquisition patterns.

4.2 SURVEY OPERATIONS AND CONTROLS

Early in the study program it was recognized that successful results would require careful planning, scheduling and control of survey operations. It was also clear that data collected in the field had to be monitored for quality, so that conclusions based on the data would be valid and meaningful.

Survey operations and controls included correspondence with participating companies, interview scheduling, aggressive follow-up of missed interviews, and interview quality control. Each participating organization was assigned a control number. Upon completion, each interview was assigned an accession number to maintain control and facilitate subsequent analysis.

Personal in-depth interviews with the 1500 users lasted an average of 1 hour and 40 minutes per interview. All interviews were conducted in private, to ensure confidentiality and to prevent bias.

The quality of the analysis depended to a great extent on the quality of the data collected during the interviews. Consequently, appropriate procedures were developed and implemented to assure consistently high quality data and to provide accurate and complete inputs for computer analysis.

Quality control extended from the interview itself, through keypunching of the data, to subsequent analysis. Interview answers were recorded both in precoded and in narrative form. To minimize errors or omissions, each interviewer was required to review and inspect the material from each interview immediately after its completion, but before the next interview. Completed interviews were sent to the project office for review and preliminary audit for completeness, consistency and coding accuracy. Immediate feedback was provided to interviewers when needed to correct errors or improve performance on subsequent interviews.

To reduce errors in transcribing data from the Interview Guide to punched cards, the Interview Guide was designed so that coded responses could be punched directly from the Guide onto cards.

An extensive procedure of manual editing and narrative response classification was carried out to ensure the maximum completeness of the data. In this manner the potential "other" and "no response" entries in an interview were largely eliminated. In addition, the computer analysis had various automatic edit and consistency checks built into its routines.

4.3 ANALYSIS OF THE DATA

The survey data consist of the reports of 1500 interviews, each containing answers to 55 questions having qualitative responses and 8 questions having quantitative responses.

Requirements and Objectives of the Analysis

An analysis should provide a bridge between the data, and meaningful guidelines for management decisions and recommendations for the future. The methods of analytical summarization employed should be sufficient to bring both the detailed and general information content of the data into proper focus. Otherwise, management will be obliged to accept only its detailed information content, or seek additional summarization to bring out its general information content. In order to achieve this:

- The analysis should first summarize the data to bring into focus its detailed information content. This summary of data, of necessity, describes only small portions of the flow process.

Table 4-1. One-Way and Two-Way Frequency Distributions

ONE-WAY FREQUENCY DISTRIBUTION

Question 22: Desired Volume of Information Media

RESPONSE	FREQUENCY (%)
All from Recall	7
One Report or Document	30
A Sampling of the Reports and Documents Available	22
All Reports and Documents That Could Be Found Pertinent to the Question	41

TWO-WAY FREQUENCY DISTRIBUTION

Question 25: Desired Depth of Information Media

Question 22: Desired Volume of Information Media

		RESPONSE		
		A Once Over Lightly	A Specific Answer	A Detailed Analysis
RESPONSE	All from Recall	0%	5%	2%
	One Report or Document	2%	18%	10%
	A Sampling of the Reports and Documents Available	3%	10%	9%
	All Reports and Documents That Could Be Found Pertinent to the Question	2%	23%	16%

- The analysis should then further summarize the data to bring into focus its general information content, so that both small and large portions of the flow process are described.

The first of these requirements can be achieved by means of frequency distributions. In addition, the second requirement can be accomplished by the analysis of relationships among the questions in the Interview Guide (which represent elements of the flow process). Such a method would yield sufficiently summarized and properly focused general information, describing both small and large portions of the flow process. To achieve this analysis, however, the qualitative data acquired in the interviews must be transformed into a numerical form.

Thus, the objectives of the analysis are:

- To provide detailed information describing small portions of the flow process.
- To transform the qualitative data into numerical form.
- To provide an analysis of relationships among questions in the Interview Guide.
- To analyze and interpret the detailed information and relationship results in order to provide meaningful guidelines for management decisions and recommendations for the future.

Outline of the Analysis Methodology

The detailed information describing small portions of the flow process is provided by frequency distributions of the answers to single questions and pairs of questions. Table 4-1 illustrates a "one-way frequency distribution" (i.e., the distribution of the percent of answers to a question that corresponds to each question response), and a "two-way frequency distribution" (i.e., the distribution of percent of answers to a pair of questions that corresponds to each pair of question responses).

As illustrated by Table 4-2, the transformation of qualitative data into numerical form is accomplished in two steps:

- A detailed structure is developed by grouping the related responses to a question and arranging these groups (and, to the extent possible, the responses within groups) into an informative order. The grouping and arranging are based on the primary characteristic of the question's responses, as determined from the responses themselves and the intent of the question.
- A numerical description of the detailed structure is defined by associating a number with each question response. The base point for a numerical scale is selected, according to the primary characteristic of the question. With each response there is then associated a numerical value, corresponding to its relative "distance" from the base point, along a scale from -1 to 1 (usually from 0 to 1).

Table 4-2. Transformation of Qualitative Data into Numerical Form

Question 14: First Source for Information

Informative Order[A]	Scale
I Received with task assignment	0
II Recalled it	0.05
III Searched own collection	0.10
IV Respondent's own action	0.15
V Assigned subordinate to get it	0.20
VI Asked a colleague	0.25
VII Asked my supervisor	0.30
VIII Requested search of department files	0.35
IX Asked an internal company consultant	0.45
X Searched company information center [B]	0.50
X Requested library search [B]	0.50
XI Requested data from vendor, manufacturer, supplier [B]	0.60
XI Searched vendor, manufacturer, supplier sources [B]	0.60
XII Searched outside library	0.70
XIII Asked an external consultant or expert	0.80
XIV Requested search of DOD Information Center [B]	0.90
XIV Searched DOD Information Center [B]	0.90
XV Asked customer	1.00

A. It is instructive to note the evolution of the responses and their order:

1. The 12 responses to Question 40 in the Phase I Interview Guide were reordered and expanded into the 16 responses to Question 14 in the Phase II Interview Guide.
2. Then the 16 responses were expanded to 18, based on an analysis of the answers to the response, "other - specify."
3. Finally the 18 responses were arranged into an informative order, according to their primary characteristic, which may be called "distance from the user."

B. No distinction is made between the two responses in this grove of related responses.

Next the analysis of relationships among questions is performed in the following four steps:

- Groups of related questions are arranged into an informative order to form a general structure. To the extent feasible, the arrangement is based on the desirable characteristic that an input question precede an output question (i.e., a question tend to influence only those questions which follow it). An example is contained in Table 4-3.

Table 4-3. Arrangement and Combination of Questions

USER COMPONENT
A. Age of User: Question 48
B. Education of User
1. Highest Degree: Question 50A
2. Field of Degree: Question 50C
3. Year of Degree: Question 50B
C. Experience of User
1. Job Experience: Question 51
2. Company Experience: Question 52
Combination of Questions: 1/2(Question 51 + Question 52)
D. Position of User
1. Kind of Position: Question 55
2. Field of Position: Question 56
E. Level of User
1. Equivalent Government Service (GS) Rating: Question 58
2. Personnel Supervised: Question 49
3. Type of Activity: Question 54
Combination of Questions: 1/2(Question 49 + Question 58)

- Pairs of related questions are combined as illustrated in Table 4-3, in order to simplify the specification and estimation of models describing the flow process. Except for rare cases in which a product is employed, all of the combinations of related questions are averages of the numbers pre·iously assigned. The scales remain between -1 and 1 (usually between 0 and 1), in all cases.

- Linear models are specified to represent potential relationships among the combinations of questions in the general structure. The models are defined in general form to include unspecified constants which, when evaluated, completely determine the model.

- Unspecified constants in the general form of the models are estimated from the data by the technique of regression analysis. Regression analysis also indicates the significance of a relationship and the relative contribution of questions to the relationship.

Finally the analysis and interpretation of the above results produces meaningful guidelines for management decisions and recommendations for the future.

4.4 COMPUTER PROGRAMS USED IN THE ANALYSIS

Two basic kinds of computer programs were used in the study:

- Special North American Aviation, Inc. programs to prepare interview data for analysis.

- Biomedical or BMD programs used in the analysis itself (see Reference 5).

Three of each kind were employed, brief descriptions of which follow.

North American Aviation Data Preparation Programs

- Creation and Updating: This program edits all inputs and creates a new tape, or updates an existing one. The answer to each question is tested for proper code limits and, in some cases, is cross-checked with answers to other questions.

- Reorder: This program assigns the sequence of coded responses, in the detailed structure, to be used for frequency distributions.

- Rescale: This program assigns the numerical values to coded responses.

Biomedical Data Analysis Programs (see Reference 5)

- Transgeneration: This program accepts data created by the Reorder or Rescale Program and combines questions, as desired, for subsequent analysis. The program was used to combine questions as specified in the general structure (see Table 4-3 and Appendices for Volume II).

- Two-Way Frequency Distribution: This program computes (a) two-way frequency distributions; (b) Chi-square value and degrees of freedom for each distribution; and (c) means, standard deviations and correlation coefficients for each pair of questions.

- Stepwise Multiple Regression: This general purpose statistical program was used to compute (a) a sequence of estimates for linear models in a stepwise manner; (b) a correlation matrix; and (c) associated significance-level information.

5. BACKGROUND

The DOD User-Needs Study was exploratory in nature. It attempted to structure and describe the nebulous process of the flow of scientific and technical information. The study has not completely solved the problems of defining, designing and operating a scientific and technical information program. Some of the reasons for this are:

- The DOD User-Needs Study was the first investigation of its size and scope dealing with a large portion of the information flow process, and its component users and tasks within major segments of the scientific and engineering community.

- The samples from Phases I and II exhibited significant differences in their users, tasks, utilization of information centers and services, and search and acquisition process.

- The Phase II analysis, although compatible with that of Phase I, was more comprehensive and definitive.

- Time and resource limitations precluded the accomplishment of more than a preliminary application of the Phase II analytical approach to the Phase II data, much less its application to the Phase I data.

- The more comprehensive and powerful analytical approach of Phase II is novel in the field of information science; and the results should be regarded as indicative, but not conclusive, and meriting additional investigation.

On the other hand, the study represents the initial step essential in developing a base of knowledge on which to build future programs. It has investigated the flow process from within, and has concentrated on the study of the user's actual experience relative to specific tasks. It has developed a (general and detailed) structure for, and models describing, the flow of scientific and technical information. This structure and these models have yielded valuable insight into the flow process and its elements.

In using and interpreting the results of this study, the following points should be kept in mind:

- Prior to these studies, no definitive description of the composition of the DOD RDT&E and defense industry populations was available. Consequently no attempt was made to select a stratified sample (this is now possible, based on the data acquired in the studies). However, the broad base and large samples used in the Phase I and Phase II studies are representative of the scientific and engineering communities studied. In fact, the Phase II data exhibited strong internal consistency.

- The study technique of investigating "critical incidents" (in this case a specific task that was recently completed by the user) ensured the acquisition of specific data on the flow process. Thus, the data acquired in the study are based on specific experiences in the interviewee's work situation, and not on his opinions, judgments and other generalities.

- The question or information areas covered in the Interview Guide were not closed-end or multiple choice. As asked, almost every question required a free response answer based on the interviewee's task-oriented experience.

- The analysis has concentrated on the over-all sample rather than its compartmentalized segments. Thus a description of particular specialists (e.g., chemists, electrical engineers, etc.), although feasible, was not attempted.

- The questions and pairs of questions dealing with INFORMATION (as opposed to those dealing with the USER, TASK or UTILIZATION) should be considered as exclusively INFORMATION descriptors, in that they are drawn from a different data base than the other descriptors (i.e., any one USER and TASK can have from one to five information units associated with them).[7]

- Conclusions involving combinations of questions should not be drawn from the frequency distributions of single questions, but only from those involving pairs of questions and the models of relationships.

- In order to analyze the data, the qualitative responses were transformed into numerical form as described in Section 4.3. One must take this transformation into account in order to apply the results of this study intelligently to information programs. If a different transformation is desired, then certain portions of the analysis should be repeated with the new transformation.

- Estimates of models describing the flow process are sensitive to changes in the detailed structure and its numerical description, and in the general structure and its combinations of related questions. The model estimates in Volume II must then be taken as relative, and not exact. However, the findings and guidelines for management decisions in Volume I have been obtained from the model estimates via an analytical technique which minimizes their sensitivity to such changes. This technique will be described in Volume II.

The present study is exploratory. Its results should be considered indicative, but not conclusive, and meriting additional investigation. It has provided a useful beginning in the definition of the design and operational criteria for scientific and technical information programs. As described in Section 3, additional experimentation and refined analysis are the next steps to undertake in the analysis and optimization of the flow process.

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[7] Twenty-four percent of the USERS performed TASKS which had an output associated with a design or design technique; but the 10 percent of INFORMATION that related to design or design techniques represents 547 of the 5359 separate information units that were used in the survey tasks. These 547 information units could have been used by anywhere from 7 percent to 36 percent of the USERS. Therefore, INFORMATION questions identify INFORMATION characteristics and not those of USER, TASK or UTILIZATION.

REFERENCES

Reference 1 contains an extensive bibliography of past user-needs studies, and Reference 2 contains a review of recent ones.

1. L. H. Berul, et al., "DOD User-Needs Study, Phase I," Volumes I & II, Auerbach Corporation Final Technical Report 1151-TR-3 (AD 615501 and AD 615502), May 1965.

2. C. A. Cuadra, Editor, Annual Review of Information Science and Technology, Volume 1, John Wiley and Sons, 1966.

3. J. C. R. Licklider, Chairman, "Report of the Office of Science and Technology Panel on Scientific and Technical Communications," February 1965.

4. J. D. Hodges, Jr., and K. H. Meyer, "DOD User-Needs Study, Phase II Interview Guide Handbook," Space and Information Systems Division, North American Aviation, Inc., Technical Report SID 65-1041-1, August 1965.

5. W. J. Dixon, Editor, BMD: Biomedical Computer Programs, Health Sciences Computing Facility, School of Medicine, University of California, Los Angeles, 1964, Revised 1965.

APPENDIX A. PARTICIPATING ORGANIZATIONS

Organization	Number of Persons Interviewed	Population of Qualified Personnel
Aerospace Corporation	25	1800
Allegheny Ludlum Steel Corporation	1	80
Allis-Chalmers Manufacturing Company	2	185
American Machine & Foundry Company	1	100
Ampex Corporation	10	760
Arthur D. Little, Inc.	7	800
Armstrong Cork Company	4	210
AVCO Corporation, Research and Development Division	31	3500
The Babcock & Wilcox Company	3	250
Battelle Memorial Institute	11	775
Bechtel Corporation	1	70
Beech Aircraft Corporation	6	470
Bell Aerosystems Company	11	1000
Bell & Howell Research Center	3	500
The Bendix Corporation	6	500
Bissett-Berman Corporation	1	65
The Boeing Company	64	6600
Colt Industries, Inc.	8	725
Cornell Aeronautical Laboratory, Inc.	6	460
Corning Glass Works	5	450
De Laval Turbine, Inc.	2	160
Douglas Aircraft Company, Inc.	66	8645
Dupont Company, Inc.	45	3200
Electric Storage Battery Company	1	200
Emerson Electric Company of St. Louis	5	325
Fairchild-Hiller Corporation, Republic Aviation Division[8]	1	
GCA Corporation, Technology Division	3	145
General Dynamics Corporation	129	13155
General Precision, Inc., Link Group	8	315
Goodway Printing Company, Inc.	3	200
Hamilton Watch Company	1	110
Hazeltine Corporation	10	800
Hercules Powder Company	23	1350
Honeywell, Inc., Aeronautical Division	12	910
HRB-Singer, Inc.	6	385
IBM, Federal Systems Division	34	3780
Ingersoll-Rand Company	1	55
Institute for Defense Analysis	15	400
Institute of Science & Technology	4	475

[8] This person had just joined the company at which he was interviewed. The interview responses reflect his position, task, etc., at Republic Aviation.

APPENDIX A. (Cont)

Organization	Number of Persons Interviewed	Population of Qualified Personnel
International Harvester Company, Solar Division	4	250
International Resistance Company	1	65
Johns Hopkins University, Applied Physics Laboratory	14	860
Kollsman Instrument Corporation	4	250
Lear-Siegler, Inc., Power Equipment Division	9	255
Leesona Moos Laboratories	1	100
Ling-Temco-Vought, Inc.	63	3500
Loral Electronics Systems	4	350
Lord Corporation	2	125
Lundy Electronics & Systems, Inc.	1	60
Management Systems Corporation	1	20
Massachusetts Institute of Technology	32	2000
Monsanto Company	44	3800
Martin Company	100	7000
McDonnell Aircraft Corporation	27	1900
Melpar, Inc.	8	900
Menasco Manufacturing Company	1	85
North American Aviation, Inc., Columbus Division	21	1570
North American Aviation, Inc., Divisions in the Los Angeles Metropolitan Area	269	18600
Northrop Corporation	29	1730
Olin Research Center	4	300
Otis Elevator Company	1	50
Philco Corporation	26	5000
Pittsburgh Plate Glass Company	3	225
The RAND Corporation	11	750
Raytheon Company	46	4000
Remington Arms Company, Inc.	3	135
Simmonds Precision Products, Inc.	2	190
Sparton Corporation, Electronics Division	1	35
Sperry Gyroscope Company	9	650
Sprague Electric Company	7	540
Stanford Research Institute	17	1220
System Development Corporation	25	850
Texas Instruments, Inc.	25	1500
Thompson Ramo-Wooldridge Inc., Equipment Laboratories	7	450
The Timkin Roller Bearing Company	5	355
United Aircraft Corporation, Norden Division	4	275
United Aircraft Corporation, Sikorsky Aircraft Division	18	1125

APPENDIX A. (CONT)

Organization	Number of Persons Interviewed	Population of Qualified Personnel
United States Steel Corporation	9	700
University of Pittsburg	7	500
University of Southern California	29	1400
Vickers, Inc.	5	380
Western Electric Company	1	120
Westinghouse Electric Corporation	22	1730
	1500	119,470

APPENDIX B. COMPARISON OF PHASES I AND II

This Appendix presents a brief comparison of the results of Phases I and II. More detailed findings will be found in Volume II. For the reader's convenience, the more descriptive terms "DOD In-House" and "Industry" will be used to denote the Phase I and Phase II studies, respectively.

In this report, continuing reference is made to three categories that are used to describe the information needed, the output of a task, and the position of the user. These categories are:

KIND: KIND refers to the area of effort or functions such as research, development, test, evaluation, production, and reliability and quality control.

CLASS: CLASS refers to the type of content such as concepts, designs or design techniques, experimental processes, performance and characteristics data, specifications and evaluation data.

FIELD: In general, there are four basic FIELDS: production and management, social and medical sciences, engineering and scientific. The Defense Documentation Center formerly classified its information into 33 subfields which relate to the technical disciplines, the processes or the products to which the information pertains. Examples are: aircraft and flight equipment, guided missiles, production and management, physics and mathematics.

1. REVIEW OF PHASE I CONCLUSIONS

The DOD In-House study produced five general conclusions:

- Engineering data is the most important category of information.
- The local work environment[4] is the most important first source for information.
- Information analysis prior to distribution is important in a scientific and technical information program.
- The DOD Information Centers and Services are not sufficiently used.
- The user is not completely satisfied with his ability to obtain information.

Results of the Industry study tend to confirm, if not strengthen, these general conclusions. Although the answers to comparable questions in the two studies exhibit significant differences (see 2 below), the general results imply similar conclusions (see Section 2). This is important because the combined DOD In-House and Industry populations represent the universe of originators and users of DOD scientific and technical information.

[4] The "local work environment" extends only as far from the user as an internal company consultant, but not as far as the company Technical Information Center, which is his connection with the formal information system (see Table 4-2).

Table B-1. General Conclusions of Phase I Versus Phase II Results

CONCLUSIONS OF DOD IN-HOUSE (PHASE I) STUDY	DOD IN-HOUSE (PHASE I) RESULTS	INDUSTRY (PHASE II) RESULTS
Engineering data is the most important category of information:		
Performance and characteristics data and specifications in the conceptual, design and performance, and production cycle.	• 42% of information needs.	• 42% of information needs.
Fields of electronics and electrical engineering, and aeronautics and space technology.	• 42% of information needs.	• 48% of information needs.
The local work environment is the most important first source for information.	• 60% confirmed this conclusion, with 39% of users' needs fully satisfied by local sources when they were the first ones contacted. • Of the formally organized information sources used, 98% (70% department files and 28% local library) were local in nature.	• 50% confirmed this conclusion, with 46% of users' needs fully satisfied by local sources when they were the first ones contacted. • Of the formally organized information sources used, 89% (34% department files and 55% company library) were local in nature.
Information analysis prior to distribution is important in any scientific and technical information program.	• 55% of needs involved "detailed analysis." • 27% of needs involved "specific answers."	• 37% of needs involved "detailed analysis." • 56% of needs involved "specific answers."
The DOD Information Centers and Services are not sufficiently used.	• Used by about 45% of DOD In-House sample. • 21% unaware of DDC; 40% unaware of TAB.	• Used by about 45% of Industry sample. • 32% unaware of DDC; 43% unaware of TAB.
The user is not completely satisfied with his ability to obtain information.	• 27% had problems in the acquisition and use of information. • 13% of users found additional task information after the task was completed.	• 42% had problems in acquisition and use of information. • 35% had problems due to restrictions on data. • 20% of users found additional task information after the task was completed.

Table B-1 shows the five general conclusions of the DOD In-House study (left-hand column), the significant statistical findings that support these conclusions (center column), and the corresponding statistical results of the Industry study (right-hand column).

2. COMPARISON OF ANSWERS TO INTERVIEW QUESTIONS

The intent of and answers to 37 of the questions asked in the DOD In-House and the Industry studies are similar enough to be statistically compared. Thirty-four of the questions (or 92 percent) revealed significant differences between the two samples, and only three questions failed to exhibit such differences. The similarities will be described first, after which the significant differences will be discussed.

Sample Similarities

The DOD In-House and Industry samples surveyed were similar in the following relatively unimportant respects:

- The proportion of the received information that was essential to the task.
- The interviewer's assessment of the user's need for information.
- The proportion of the user's work-time spent in accomplishing the task.

Summary of Differences

The survey questions which revealed the greatest differences between the two samples were in the search and acquisition process. Significant variations were also found in the utilization of information centers and services, and in the task and user characteristics. The important differences within these areas are as follows:

a. In the search and acquisition process (Figure B-1), the Industry users:

- Wanted and received all the information available and a specific answer more often, while relying less on recall and single documents; also, they wanted and received less data in the form of detailed analyses and once-over-lightly presentations.
- Received less information with the task assignment than was the case with users in the DOD In-House survey and were less dependent upon their local work environment for task information. However, they went beyond the local work environment only 20 percent of the time.
- Tended to use a first source more because it was available or the only source known, and less because they were told or recalled that information was available from that source.

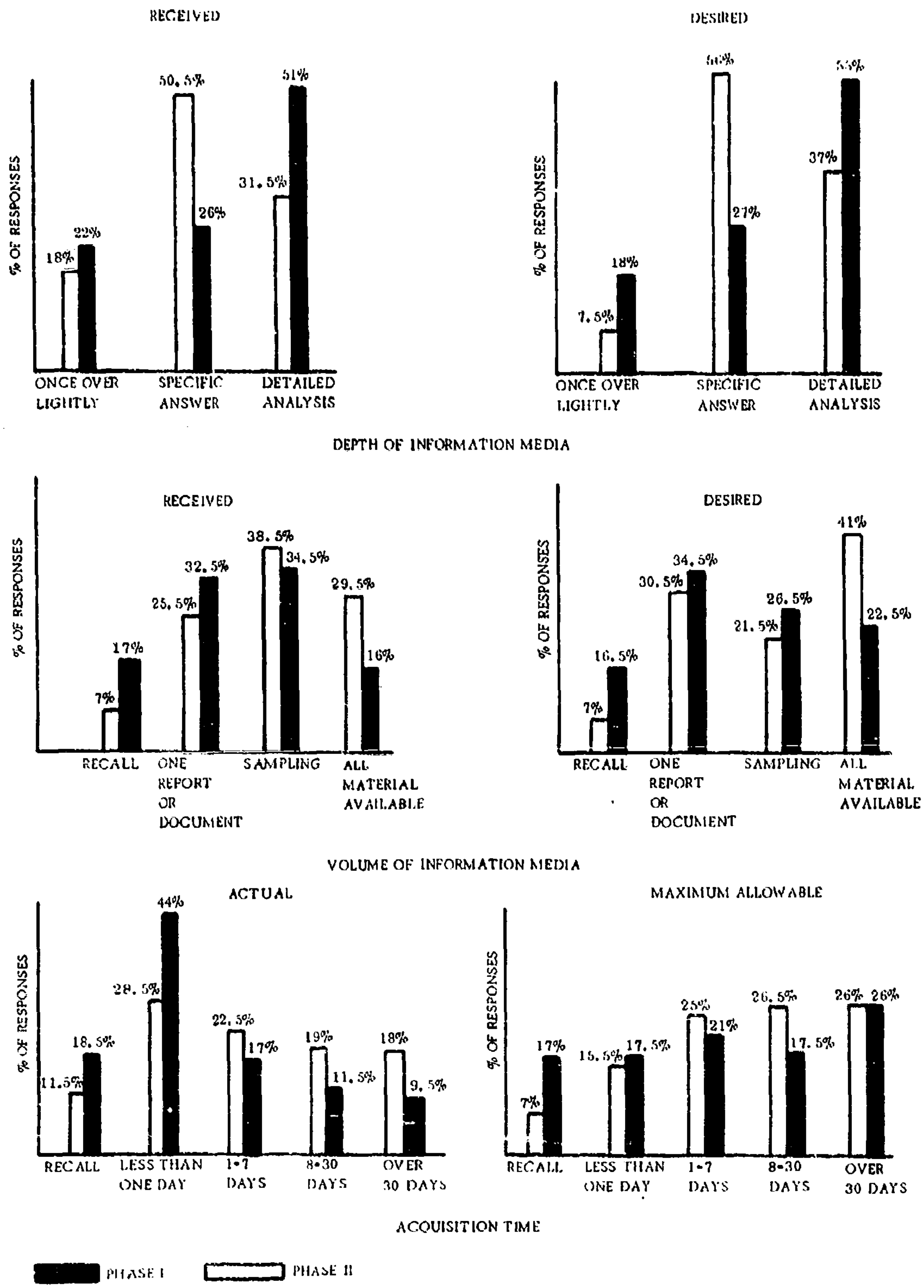


Figure B-1. Comparison of Phases I & II - Search and Acquisition

- Were less subject to time constraints in the acquisition of information; the Industry users could and did take longer to gather their information.
- Found post-task information more often than users in DOD In-House sample.
- Used their information more directly in task accomplishments and less as background information.

b. In the use of information centers and services, the Industry users:

- Encountered more problems in the acquisition and the use of information (Figure B-2).
- Were more often unaware of the availability of the DDC, TAB, etc. (but a greater percentage of those who knew of these services used them).

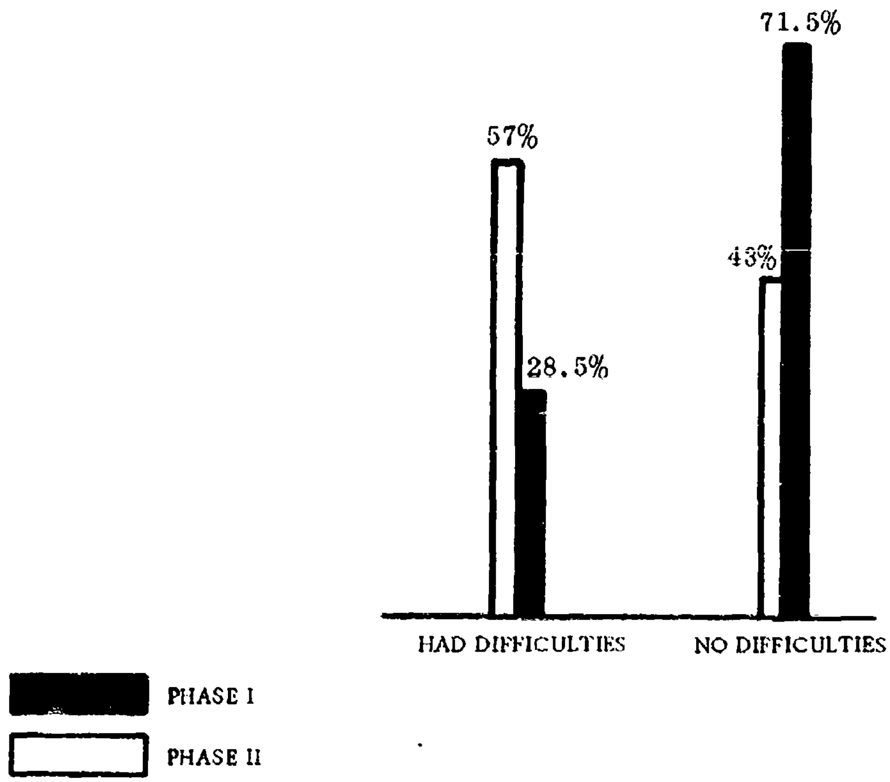


Figure B-2. Comparison of Phases I and II - Utilization Difficulties

c. The tasks in the Industry sample (Figure B-3):

- Involve fewer self-generated tasks and more tasks directed outside the DOD or company.
- Deal more with concepts, design, production, research, aerospace, aircraft, electronics and propulsion systems. On the other hand, the DOD tasks are more concerned with test processes and procedures, costs, funding, administrative action, operational development, ordnance, medical science and communications.
- Involve a larger number of formal and written task outputs.
- Involve a longer task duration.

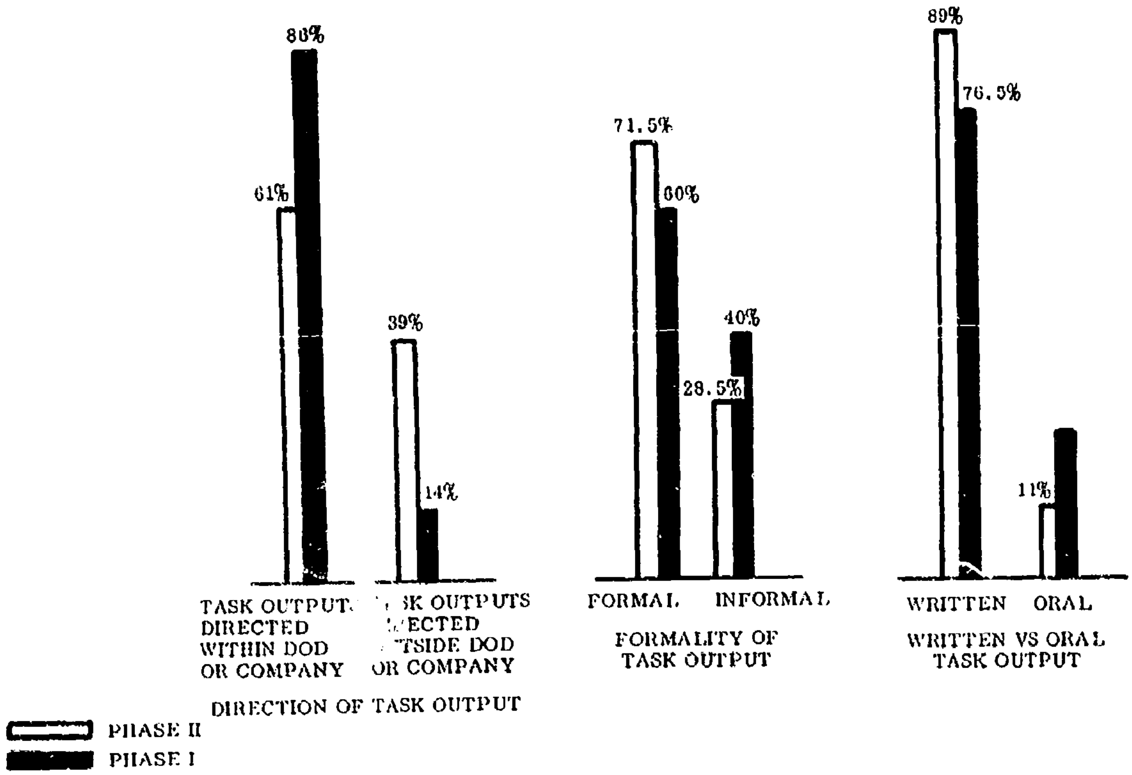


Figure B-3. Comparison of Phases I & II - Task

d. The users in the Industry sample (Figure B-4):

- Have a younger median age.
- Earned more post-graduate degrees.
- Have been in their present kind of work longer.
- Are more involved in administration and technical management.
- Are in higher salary levels than those in the DOD In-House sample.

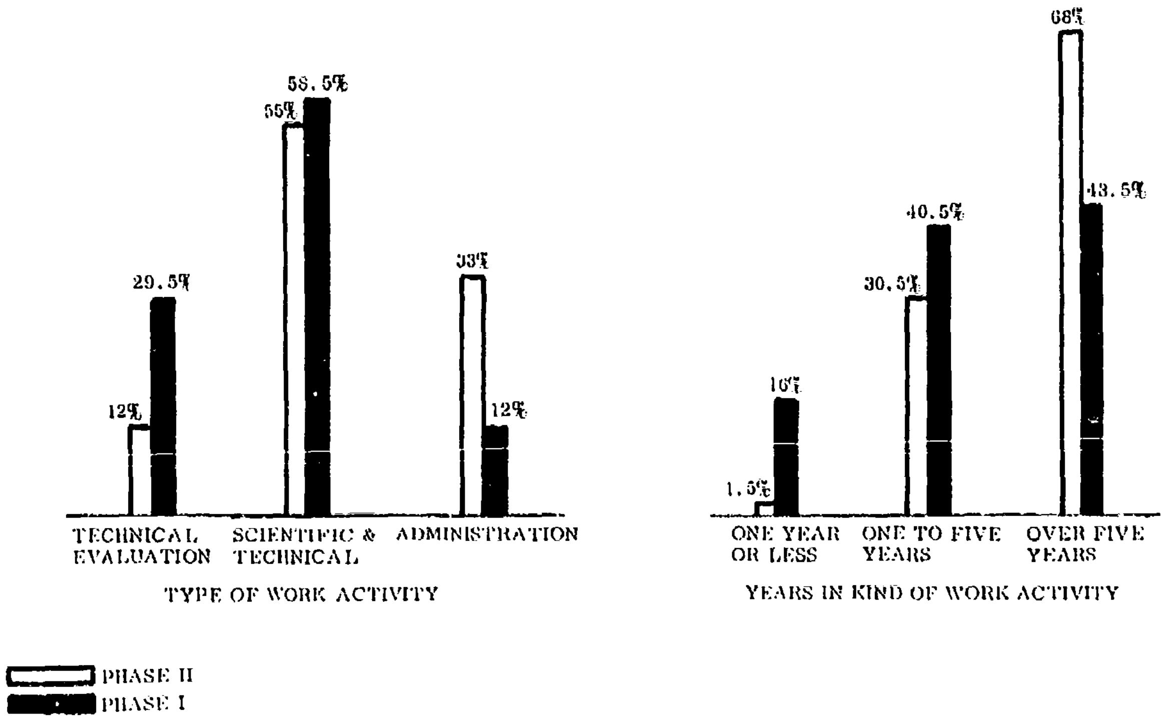


Figure B-4. Comparison of Phases I & II - User

3. COMPARISON OF ANSWERS TO PAIRS OF QUESTIONS

The Phase I Final Report (Reference 1) discussed 46 pairs of questions in which the answers to one question (such as "Type of Activity") are distributed against the answers to another question (such as "Do you use DDC ?"). In this example, such an analysis would reveal any tendency of users involved in a particular activity to make different use of the DDC than users in another activity.

In the present Industry study, 43 of these potential relationships were investigated and the findings compared with those of the DOD In-House study. It was found that the DOD In-House results are contradicted by those of the Industry study about as often as they are substantiated. This, however, is not surprising in view of the many differences between the two samples, as demonstrated above.

General Areas of Agreement

The areas in which the Industry findings agree with the DOD In-House results relative to pairs of questions are as follows:

- As the desired volume of information increases, the required acquisition time also increases.
- No relationship exists between the discovery of post-task information and user attributes (such as salary, education, kind of activity, etc.).
- A high portion of research tasks are found in the fields of medical science and physics, in the utilization of concepts, and in situations involving the use of libraries as a first source.
- About 25 percent of the users are called upon to perform tasks that are outside their normal kind or field of work activity. This tendency is greatest for workers in the field of mathematics, and least for those in the medical sciences.
- Individuals having advanced degrees (i.e., having more background and training) report more problems in the acquisition and use of information.

Areas of Major Difference

The meaningful areas in which differences were found are outlined below. In each instance, the earlier DOD In-House study indicated either no significant relationship, or a specific contradicting characteristic. The study of the Defense Industry showed that:

- The need for performance and characteristics data is approximately uniform throughout all phases of the research, development and production cycle; that is, the need for such data occurs about as often in the early phases as in the later phases.
- As the desired volume of information increases, the use (or potential use) of title listings and abstracts increases.

- The discovery of post-task information is not related to the phases of the research, development and production cycle, or to the field of activity of the user (such as production and management, engineering or scientific).

- As the work proceeds away from research and toward an end product, there is less need for depth in information.

- Longer task durations are related to the use of first sources for information that are more distant from the user, and longer acquisition times for information.

- It takes longer to acquire information whose first source is more distant from the user.

- The higher the user's salary level and importance to his company, the more he tends to encounter problems in the acquisition and use of scientific and technical information.

The DOD In-House and Industry scientific and engineering communities are apparently different in many individual aspects. However, as general users of scientific and technical information, they exhibit many similar tendencies and relationships. It is, therefore, desirable to apply the more powerful analysis of Phase II to the Phase I data and the combination of Phase I and Phase II data.

APPENDIX C. SUMMARY OF PHASE II FINDINGS

Refer to the beginning of Appendix B for the definitions of kind, class and field.

1. THE SEARCH AND ACQUISITION PROCESS

In studying the search and acquisition process, the answers to the following questions are of prime interest:

- What information is involved?
- By what media does the user desire to receive the information?
- To which source does the user go first?
- When is the formation needed? When is it acquired?

This portion of Appendix C presents the more significant findings relating to these questions.

What Information Is Involved?

The class of information was over 60 percent design and performance (Figure C-1).

Figure C-2 shows that almost half of the information was in the engineering field, and almost 40 percent was in the scientific field.

As would be expected, the class and field of information required for the task are mostly related to the kind, class and field elements of the task. When the potential relationships within the search and acquisition process are considered, the class and field of information are not significantly related to the other descriptors (such as media, etc.). They, therefore, identify information areas and not necessarily other search and acquisition characteristics.

By What Media Does the User Desire to Receive the Information?

The significant characteristics of the desired media for conveying information are defined in terms of their formality (composition and layout), volume (extent) of documentation and depth of detail (Figures C-3 and C-4):

- More than one out of three users desired to receive information orally, and more than one out of three users desired to receive it semiformally written.
- Almost three out of five users desired a textual layout.
- More than three out of five wanted more than one document.
- Almost all users wanted more detail than once over lightly (almost three out of five wanted a specific answer).

The volume and depth of information received was less than that desired in about one-seventh of the cases.

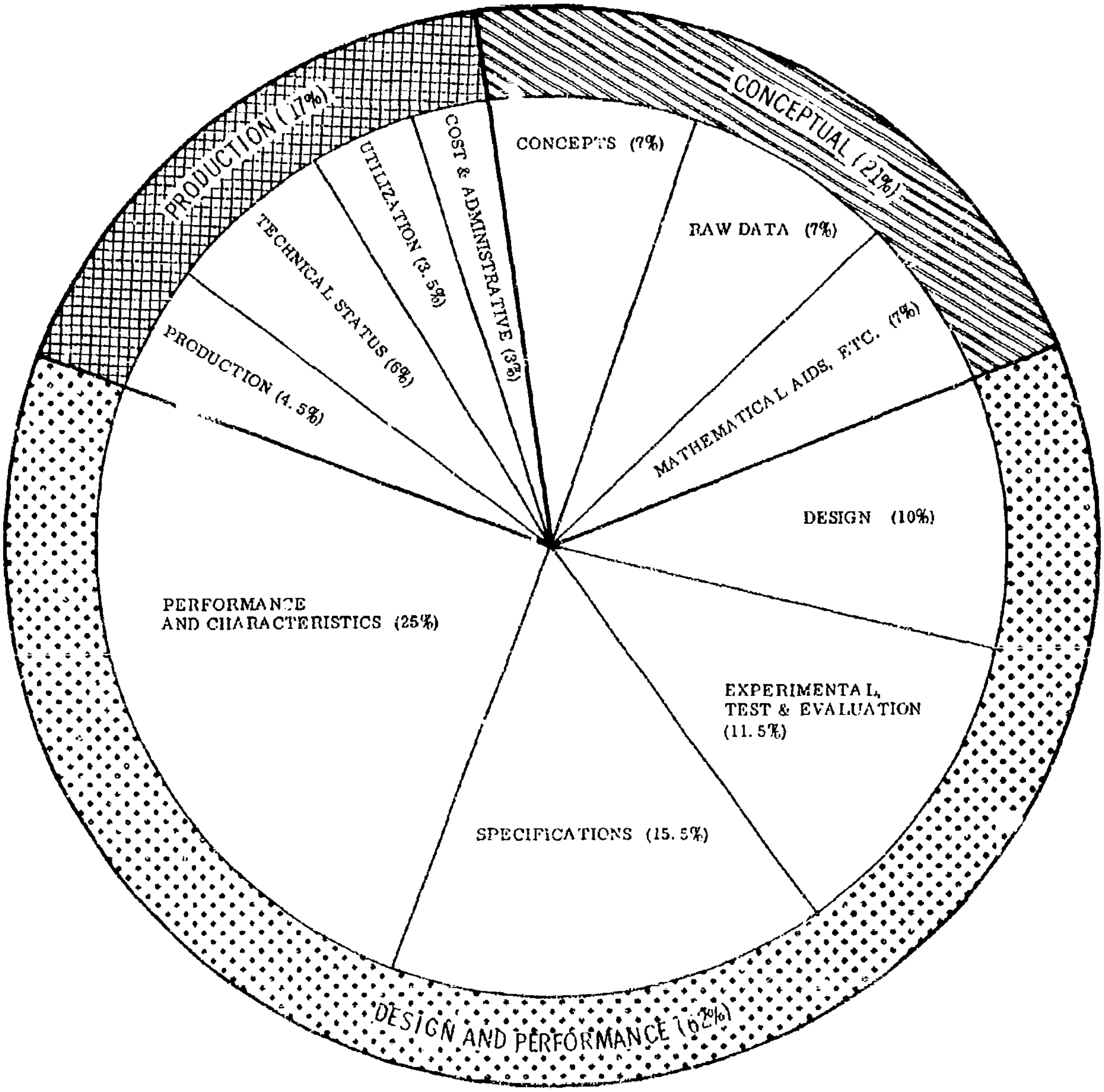


Figure C-1. Class of Information

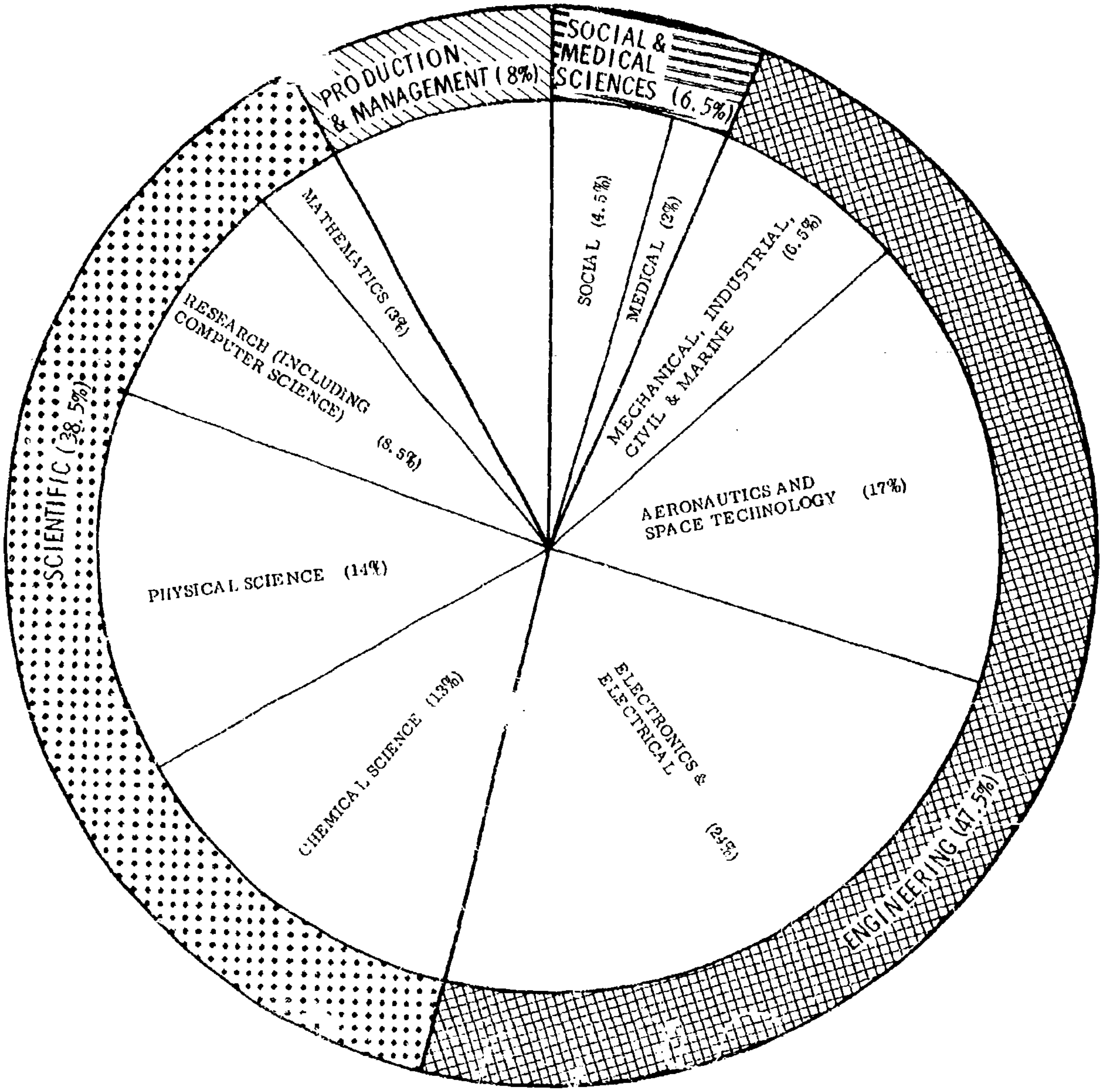
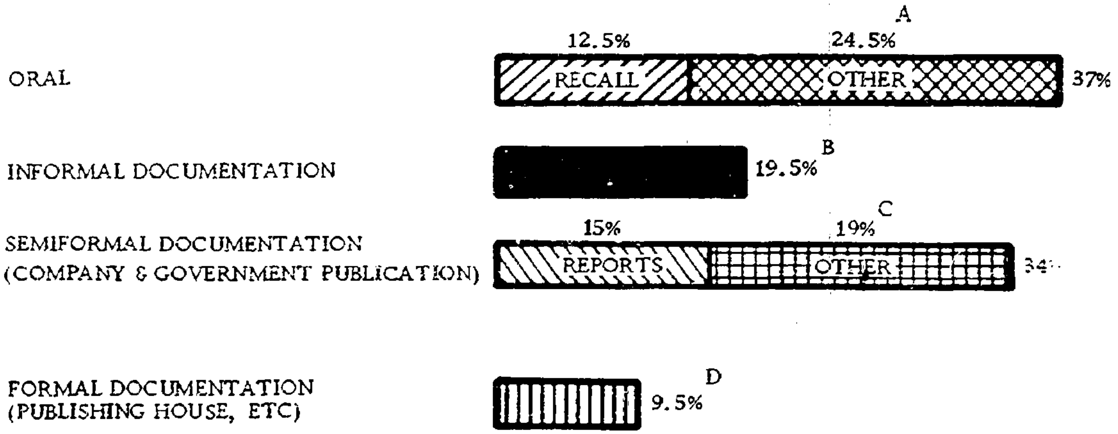


Figure C-2. Field of Information



A. THOSE RESPONSES WITH OVER 3 PERCENT ARE: "ORAL CONTACTS-ALL OTHER" (18%) AND "ORAL CONTACTS WITH MANUFACTURER" (3.5%).

B. THOSE RESPONSES WITH OVER 3 PERCENT ARE: "PERSONAL NOTES, PERSONAL LOGS AND PERSONAL FILES" (3%); "CORRESPONDENCE, MEMOS AND TWX" (6%); AND "DRAWINGS AND SCHEMATICS" (5%).

C. THOSE RESPONSES WITH OVER 3 PERCENT ARE: "SYSTEM SPECIFICATION DOCUMENT (QMR, TDP, ETC)" (4.5%) AND "MANUALS" (3.5%).

D. THOSE RESPONSES WITH OVER 3 PERCENT ARE: "JOURNALS" (4.5%) AND TEXTBOOKS" (3.5%).

Figure C-3. Desired Formality for Information Media

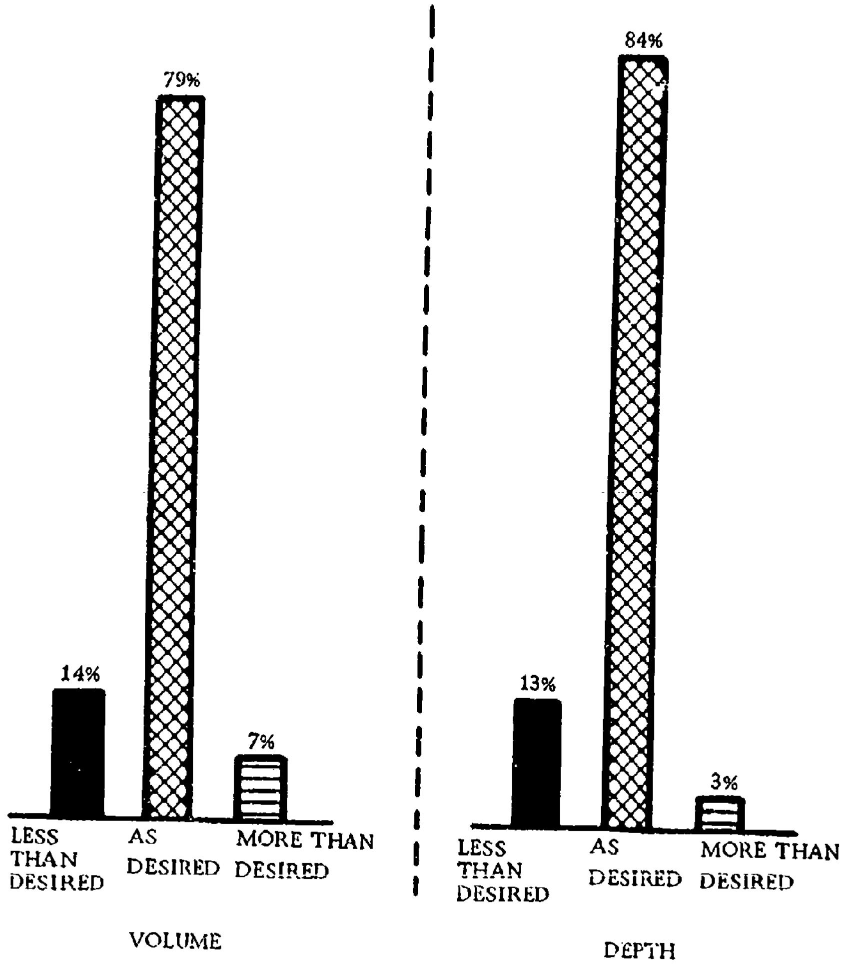


Figure C-4. Volume and Depth of Information Media

The analysis revealed a significant relationship which indicates that the desired composition and layout of the media is mainly related to the desired extent of the media which, in turn, largely depends on the duration of the task.

To Which Source Does the User Go First?

About 30 percent of the user's needs were satisfied without search, and 50 percent were sought within his local work environment (Figure C-5). These first sources almost always yielded part or all of the information needed.

The following significant relationships were found regarding the first source that was used:

- The particular first source used is mainly related to the reason for its use and the composition and layout of the media. The sources more remote from the individual were used more often when they were known to have the desired information and for the more formally documented information.

- As allowable acquisition time increases, there is a tendency to use first sources that are at a greater distance from the user.

- What was acquired from the first source depends on the desired composition and layout (formality) of the medium from which the information was to be obtained, and the amount of time available. As the desired formality and time available increased, the amount of information gained from the first source decreased.

When Is the Information Needed and Acquired?

Almost 75 percent of the information is needed within 30 days, while over 80 percent is acquired within 30 days (see Figure B-1). With the exception of 5 percent, the information needs were satisfied within the allowable acquisition time (Figure C-6).

The following relationships were found involving the time by which information was needed and the time by which it was acquired:

- The allowable time for the acquisition of information is most related to the duration of the task.

- The time to acquire the information is mainly related to the duration of the task, and the desired composition and layout of the media.

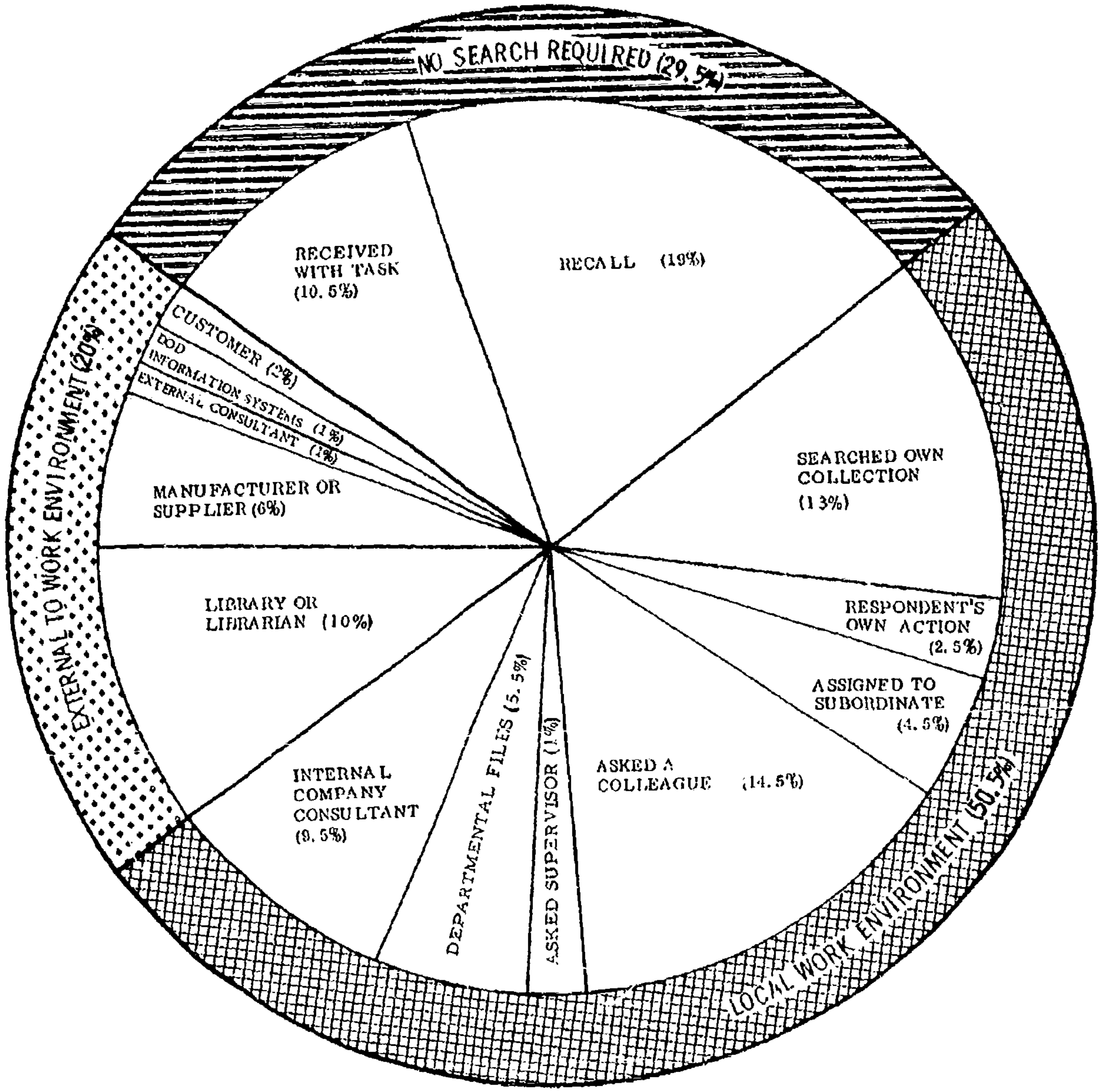


Figure C-5. First Source Contacted for Information

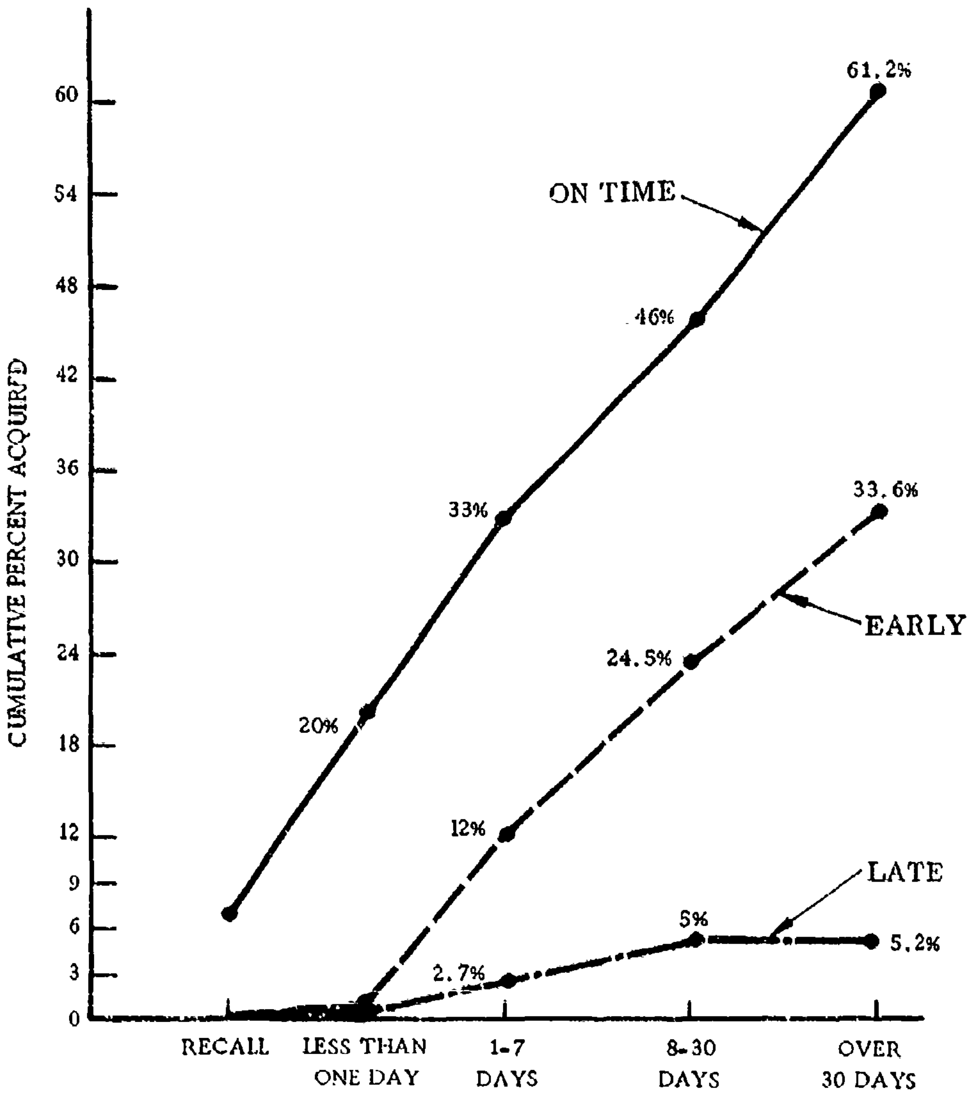


Figure C-6. Timely Acquisition of Information

Miscellaneous Questions: How Useful Are Abstracts? How Often Is There Late Discovery of Information? How Inadequate Is the Search and Acquisition Process?

- Title listings or abstracts would have been useful for finding more than 40 percent of the user's information requirements.

- In general, the usefulness of title listings or abstracts depends mainly on the desired composition and layout of the media for conveying information and the effort which the user devotes to the utilization of information centers and services.

- For one out of five tasks, information that was available, but unknown, during the task was discovered too late to be useful.

- Those users who encountered problems in the use of information centers and services were the ones most likely to discover information that was available, but unknown to them, during work on a task.

- In general, the inadequacy of the search and acquisition process (as measured by the inability of the user to obtain information in the form, depth, volume, time, etc, desired) is most related to the duration of the task; the inadequacy increases as task duration increases.

2. THE UTILIZATION OF INFORMATION CENTERS AND SERVICES

The more significant findings concerning the utilization of information centers and services, and problems which the users have encountered in this utilization are now presented.

The Utilization of Information Centers

- The company Technical Information Centers are utilized by almost all industry users of scientific and technical information.

- The Defense Documentation Center (DDC) is utilized by almost one half of the users (Figure C-7).

- On the other hand, the DDC is unknown to almost one out of three of the users (Figure C-7).

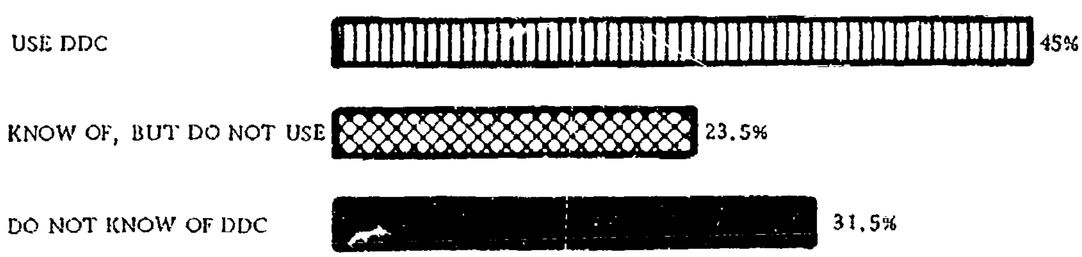


Figure C-7. Use of Defense Documentation Center

- Over 40 percent of the users of scientific and technical information make use of the DOD Specialized Information Centers (Figure C-8).
- On the other hand, the DOD Specialized Information Centers are unknown to more than one-third of the users (Figure C-8).

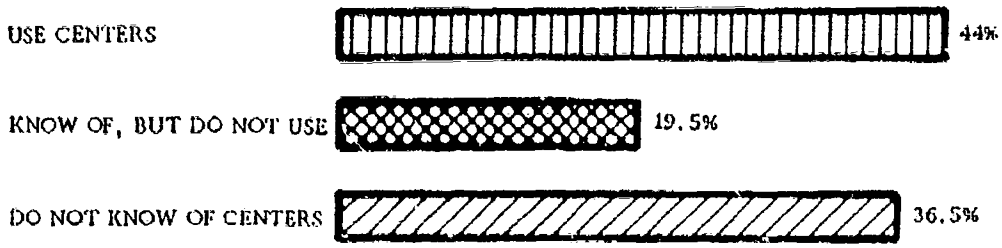


Figure C-8. Use of DOD Specialized Information Centers

- Other Specialized Information Centers are utilized by almost one-third of the users.

Significant relationships which bear on the utilization of various information centers were revealed in the analysis of data. They are:

- The extent to which company Technical Information Centers are used is most related to the user's kind of work; they are used more by users in the early phases of the research, development and production cycle than by those later in the cycle.
- The users of the DDC also tend to make corresponding use of DOD and other Specialized Information Centers.
- The higher the user's level and value to his company, the more use he tends to make of the DOD and other Specialized Information Centers.

The Utilization of Information Services

- The Technical Abstract Bulletin (TAB) is used by more than one-third of the users of scientific and technical information (Figure C-9).
- The TAB is unknown to over 40 percent of these users (Figure C-9).
- The National Aeronautics and Space Administration (NASA) Scientific and Technical Aerospace Reports (STAR) are utilized by almost 20 percent of the users of scientific and technical information.[9]
- The STAR is unknown to almost two-thirds of the users.
- English abstracts and translations of foreign literature are used by almost 40 percent of the users.

Significant relationships which bear on the use of the various information services are:

- The use of services is interrelated - the users of one service, such as the TAB, are more than likely the users of other services.
- The use of services is related to the work level of the user, as measured by (a) highest degree; (b) position in the research, development and production cycle; and (c) salary level.

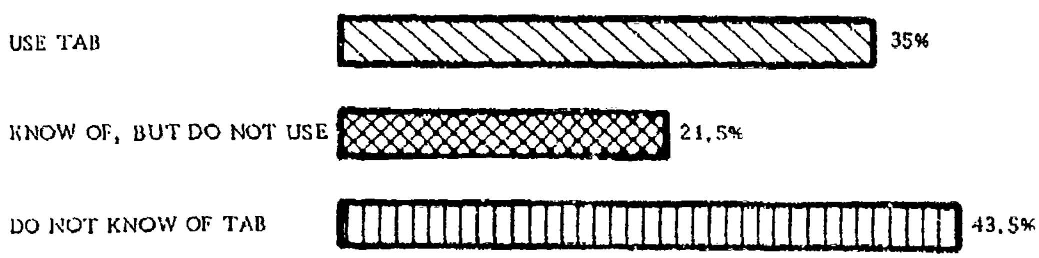
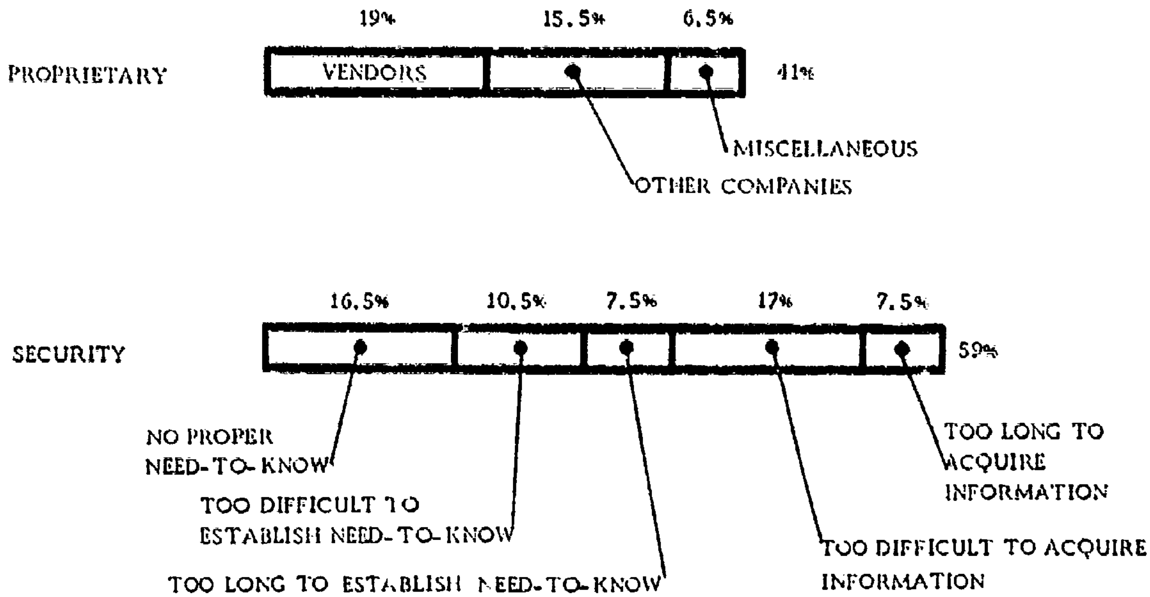


Figure C-9. Use of Technical Abstract Bulletin

[9] It should be noted that Phase II was concerned with DOD contractors, who may or may not be NASA Contractors.

Problems Encountered in the Use of Information Centers and Services

- Over one out of three users encounter proprietary or security restrictions, with 60 percent being concerned with security (Figure C-10).



*BASED ON THE 451 APPROPRIATE NARRATIVE ANSWERS, OF THE 525 ANSWERS TO THE QUESTION.

Figure C-10. Nature of Restrictions

- Timely awareness, timely acquisition or utility of information difficulties are encountered by over two out of five users. Almost two-fifths of these difficulties involved timely awareness of information, and over half of them involved timely acquisition of information (Figure C-11).

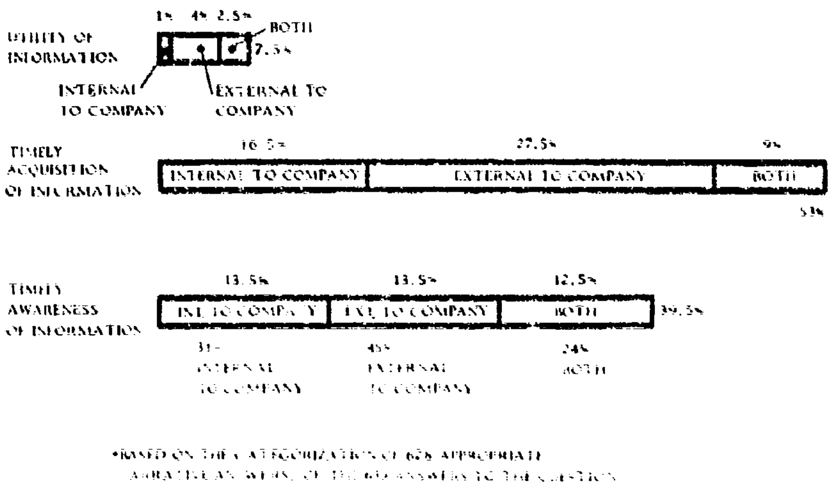


Figure C-11. Nature of Difficulties

- Timely awareness difficulties are evenly divided between being internal and external to the company, while timely acquisition and utility difficulties are much more often external than internal.

- The solutions, suggested by the users, for these difficulties (Figure C-12) support the guidelines for management decisions of Section 2.

The following significant relationships were found regarding the encounter of problems in the acquisition of information:

- The encounter of problems (restrictions and difficulties) was related to the use of information centers and services. Those users who were more involved in the use of information centers and services encountered and reported more problems than those who made less use of these facilities.

- The higher level individuals encountered and reported more problems.

3. THE SCIENTIFIC OR TECHNICAL TASK

The analysis of the scientific or technical task was concerned with the major output of the task, and the duration and intensity of effort for the task.

Major Output of the Task

The major output of the scientific or technical task is described in terms of the categories of kind, class and field.

- By kind, two-thirds of the tasks are concerned with the development function (Figure C-13).

- By class, two-thirds of the tasks involve design and performance data.

- By field, more than one-half of the tasks involve engineering and one-third of them involve scientific activity.

The major relationships identified are as follows:

- The kind and class of the major output of the tasks are closely identified with the user's kind of work activity. It was found that 44 percent of the users changed from one kind of work activity to tasks whose major output was of another kind. The cross-over is lowest for basic research and reliability and quality control personnel, and highest for engineering development and customer relations personnel.

- The field of the major output of a task is most closely identified with the field of the user's work activity. On the average, 27 percent of the personnel left their normal field of work activity to carry out a task that was basically in another field. Twenty-five percent of all cross-overs were into aeronautics and space technology. The least amount of cross-over was from the medical sciences (13 percent) and chemical sciences and materials (17 percent). The greatest amount of cross-over was from mathematics (56 percent)

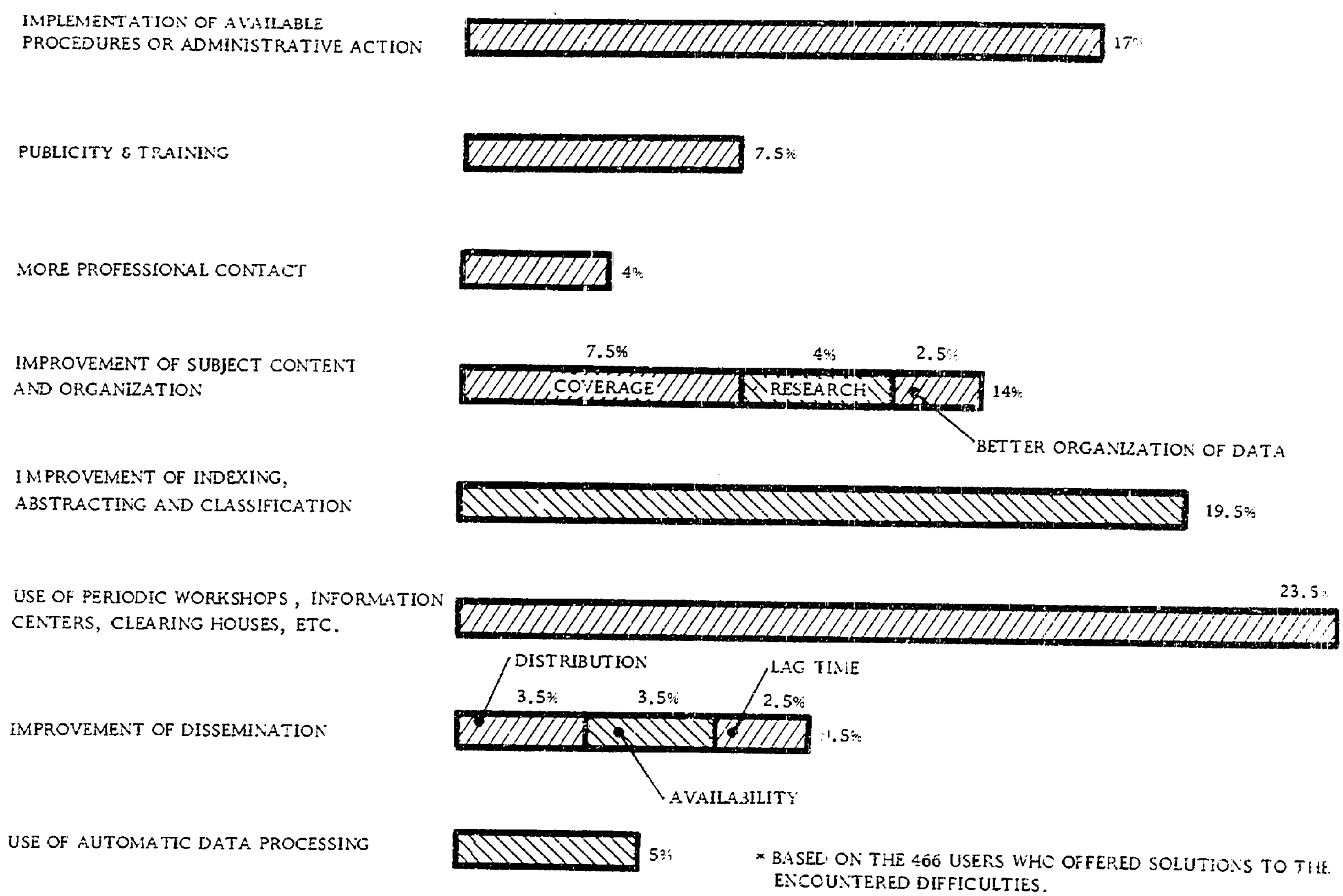


Figure C-12. Solutions for Difficulties

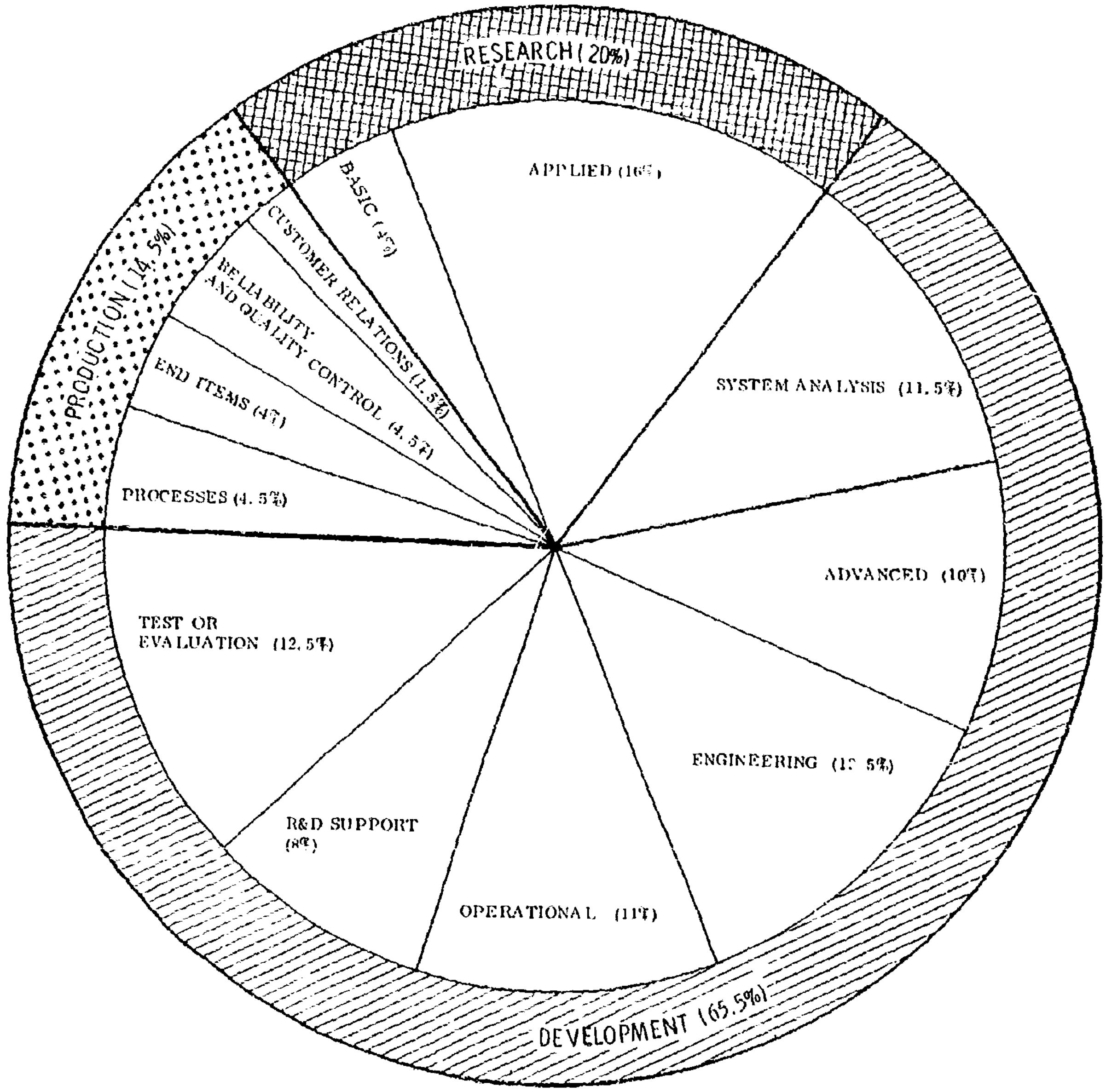


Figure C-13. Kind of Task

The major output of more than 50 percent of the tasks was presented in a document, while more than 70 percent of the major task outputs (both documented and oral) were formal in nature (Figure C-14).

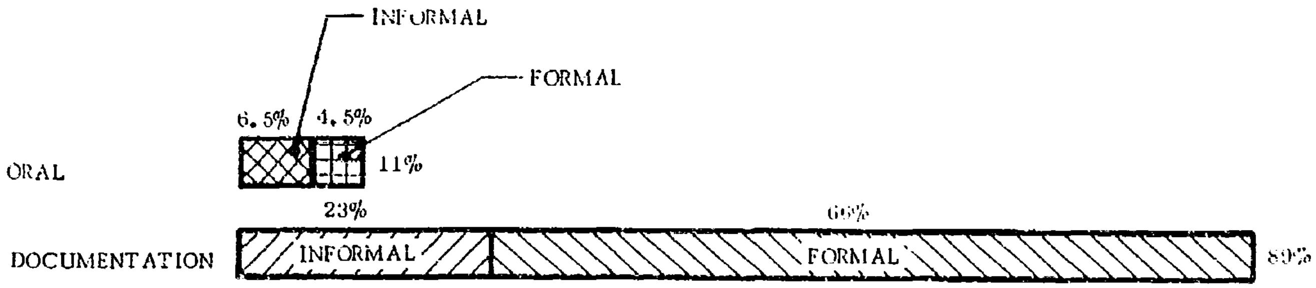


Figure C-14. Formality of Task Output

Figure C-15 shows that the major output of more than 50 percent of the tasks was a finding.

The analysis revealed a significant relationship indicating that the formality and type of the major output of a task are mostly related to the level of the user in his company, and the recipient of the task output.

Duration and Intensity of Effort for Task

- Almost one-half of the tasks were from one to six months in duration, and almost 40 percent were one month or less (Figure C-16).

- The percent of the user's time devoted to tasks tends to be uniformly distributed.

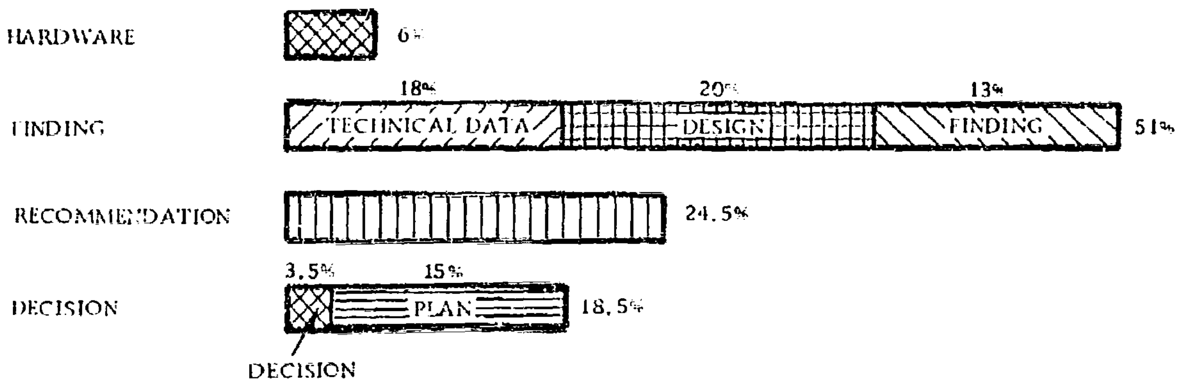


Figure C-15. Type of Task Output

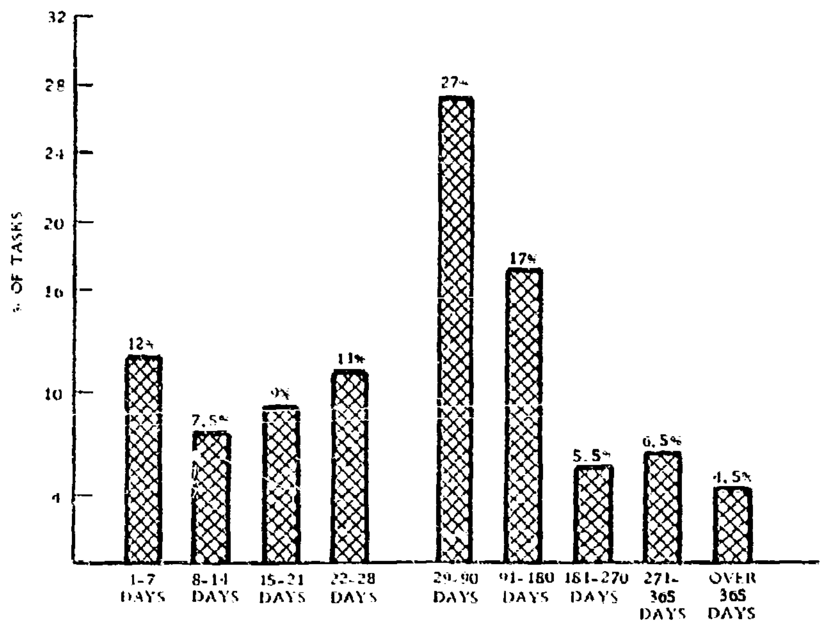


Figure C-16. Task Duration

The analysis disclosed a relationship indicating that the duration of a task tends to be greater during the earlier phases of the research, development and production cycle.

4. THE USER OF SCIENTIFIC AND TECHNICAL INFORMATION

The analysis of the user of scientific and technical information was concerned mainly with what he does and who he is.

What He Does

- Two out of three users are in development work.
- Over half of the users are engaged in engineering activity and more than one-third of them are engaged in scientific activity.
- The higher the user's degree, the more likely he is to be involved in work occurring earlier in the research, development and production cycle.
- The field of the user's position (i.e., production and management, engineering or scientific) is most related to the field of his highest degree.

Who He Is

- More than half of the users possess a bachelor's degree and almost one out of three users possesses an advanced degree.
- Two out of five users are in nonsupervisory positions and one out of three users supervises from one to five persons.
- Three out of four users are in salary levels corresponding to the Government Service GS-11 to GS-14 level (and then tend to be uniformly distributed within that range).

Significant relationships among user attributes are:

- Although the user's age is not significantly related to his highest degree, his age is related to the field of his highest degree. Younger persons hold more degrees in mathematics and science, while the older ones have more degrees in engineering fields.
- The equivalent GS rating of the user's salary level is most related to his highest degree.

5. SIGNIFICANT FACTORS WITHIN THE FLOW PROCESS

The comparison of Phases I and II in Appendix B has been made in terms of small portions of the flow process (i.e., answers to comparable questions and pairs of comparable questions). A unique result of the industry study is the identification of significant factors within the flow process. These factors will be described from a systems design point of view.

It is quite informative to consider the input/output relations among the USER, TASK, UTILIZATION and SEARCH AND ACQUISITION components of the flow process and among questions contained in them (see Section 2.5). Depending upon the portions of the flow process under consideration, a given component or question may sometimes be thought of as an input (i.e., tending to influence) and sometimes be thought of as an output (i.e., tending to be influenced). Figures C-17 through C-21 depict these input/output relations.

Refer to the beginning of Appendix B for definitions of kind, class and field.

The Search and Acquisition Process (see Figure C-17)

The factors that best describe SEARCH AND ACQUISITION are:

- The input factors represented by the class and field of information; and the desired composition, layout, volume and depth of the medium conveying the information.
- The output factors represented by (a) the first source for the information and what is acquired from it, (b) when the information is needed and acquired, (c) how useful are abstracts, (d) how often is there late discovery of information, and (e) how inadequate is the search and acquisition process.

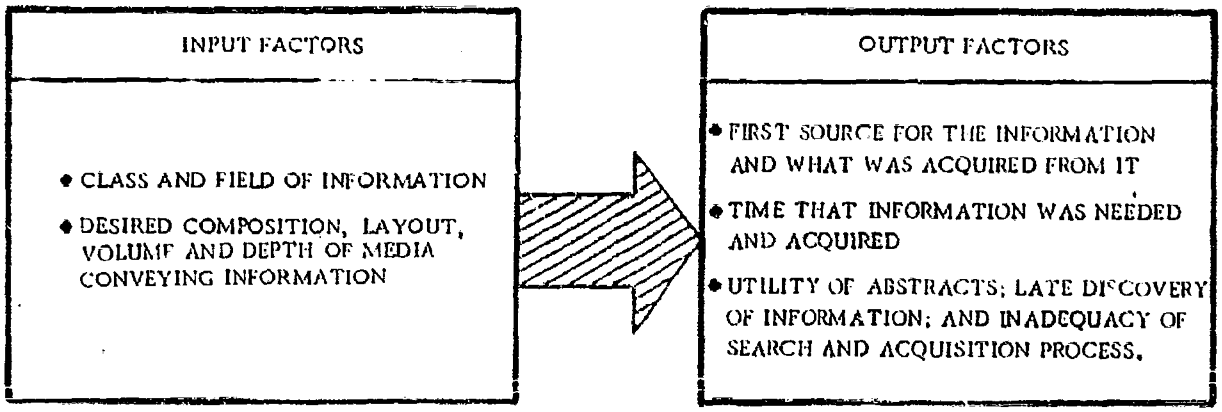


Figure C-17. Input/Output Relations for the Search and Acquisition Process

In general, the USER, TASK and UTILIZATION components act as inputs to SEARCH AND ACQUISITION. (See the arrows marked 4 in Figure C-21). Those factors that are most related to SEARCH AND ACQUISITION are, in order of their significance:

a. The extent to which the user employs information centers and services.

b. The desired composition and layout of the media for conveying information.

c. The desired volume and depth of the conveying medium.

d. The kind and class of the major output of the scientific and technical tasks.

The Utilization of Information Centers and Services (see Figure C-18)

The factors that best describe UTILIZATION are:

- The input factors represented by the use of the (a) company Technical Information Center, (b) Defense Documentation Center, (c) DOD and other Specialized Information Centers, (d) Technical Abstract Bulletin, (e) Scientific and Technical Aerospace Reports and (f) English abstracts or translations.

- The output factors represented by the (a) restrictions and difficulties encountered by the user in his utilization of information centers and services, (b) extent to which the user utilizes information centers and services, and (c) extent to which the user encounters restrictions and difficulties in this utilization.

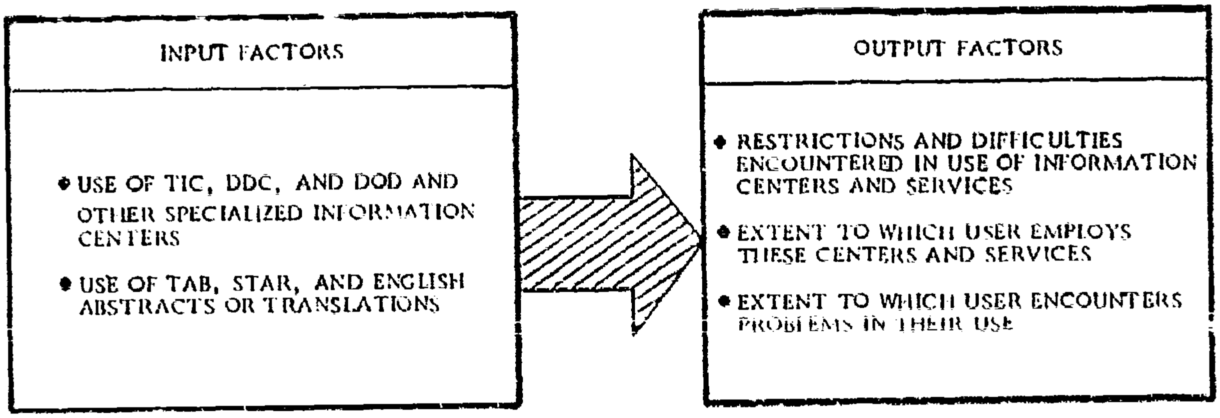


Figure C-18. Input/Output Relations for the Utilization of Information Centers and Services

In general, the USER component acts as an input to UTILIZATION (see arrow 3 in Figure C-21). Those factors most related to UTILIZATION are, in order of their significance:

a. The user's kind of position.

b. The user's salary level and number of people he supervises.

c. The user's highest degree.

The Scientific or Technical Task (see Figure C-19)

The factors that best describe the TASK are:

- The input factors represented by the kind, class and field of the task's major output.
- The output factors represented by the formality and type of the task's major output and the duration of the task.

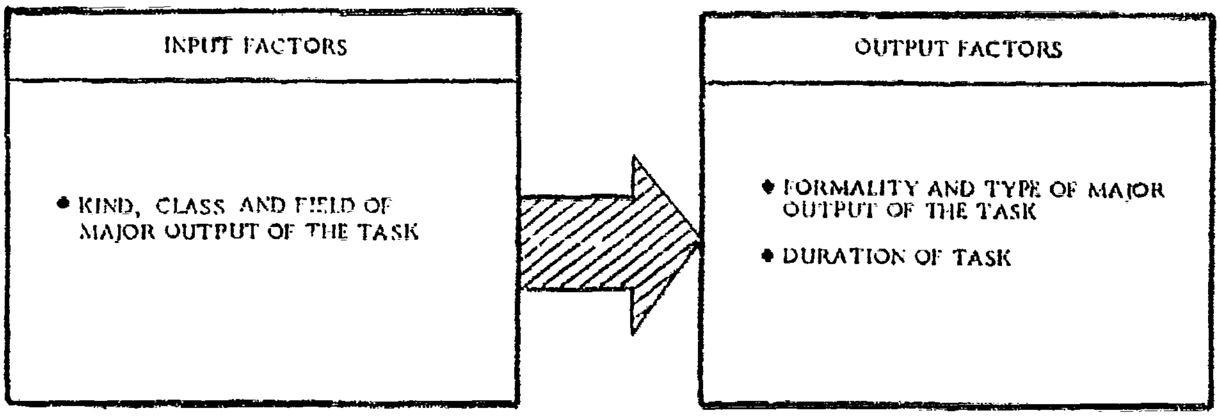


Figure C-19. Input/Output Relations for the Scientific or Technical Task

In general, the USER component acts as an input to the TASK (see arrow 2 in Figure C-21). Those factors most related to the TASK are, in order of importance:

a. The user's kind of position.

b. The kind and class of major output of the task.

The User of Scientific and Technical Information (see Figure C-20)

The factors that best describe the USER are:

- The input factor represented by the user's highest degree.
- The output factors represented by (a) the kind and field of the user's position, (b) the number of people he supervises and (c) his salary level.

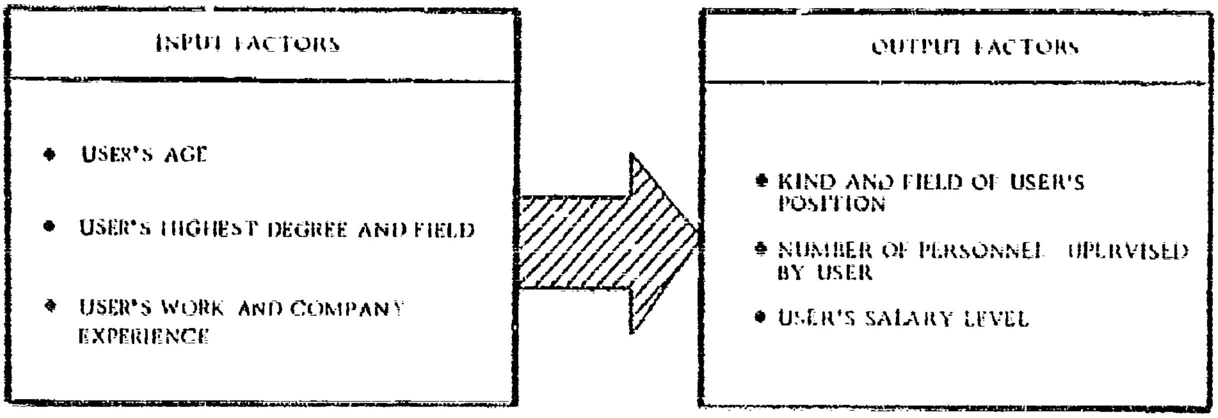


Figure C-20. Input/Output Relations for the User of Scientific and Technical Information

<u>The Flow Process</u> (see Figure C-21)

The factors that best desribe the FLOW PROCESS are (see arrow 1 in Figure C-21):

- The input factors represented by questions contained in the USER and TASK components.
- The output factors represented by questions contained in the UTILIZATION and SEARCH AND ACQUISITION components.

The flow process is the combination of the USER, TASK, UTILIZATION, and SEARCH AND ACQUISITION components. Those factors that are most related to this combination of components are, in order of their significance:

a. The user's kind of position.

b. The user's highest degree.

c. The user's salary level and number of people he supervises.

d. The kind and class of the major output of the task.

e. The extent to which the user employs information centers and services.

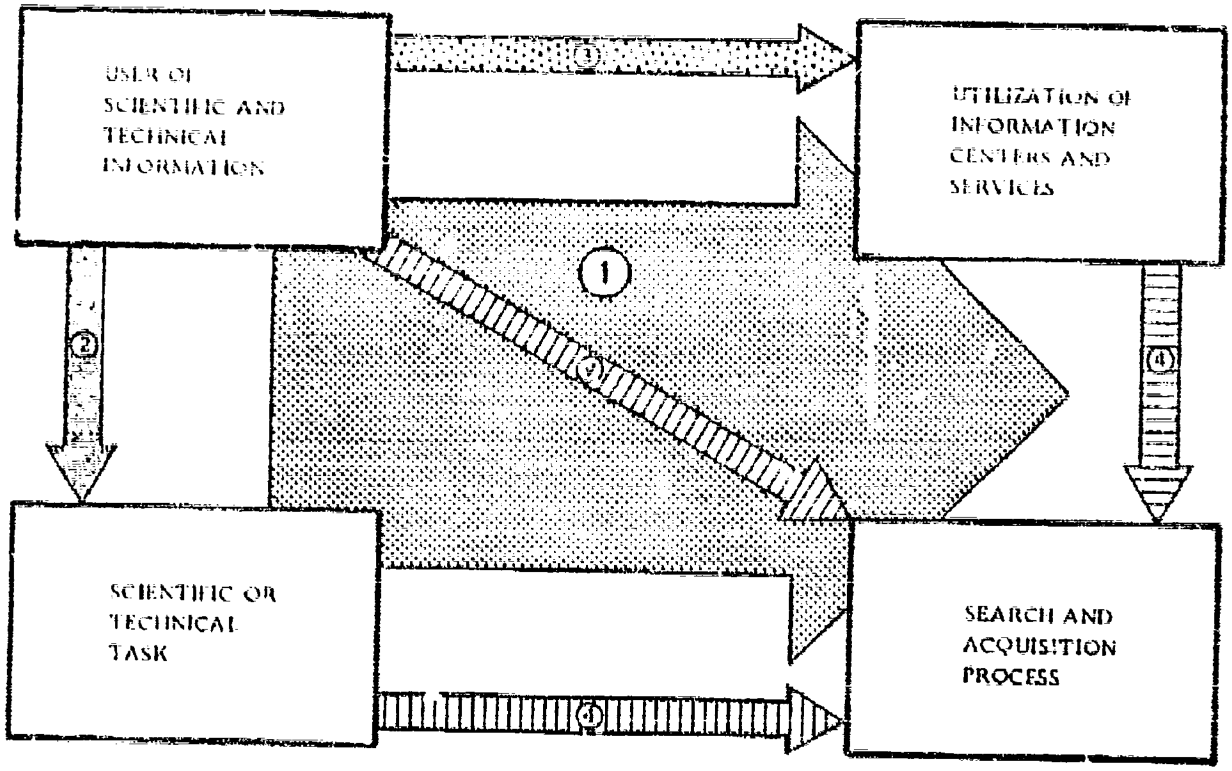


Figure C-21. Input/Output Relations for the Flow Process

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13. ABSTRACT

The Department of Defense (DOD) has conducted a two-phase study to determine how scientists and engineers in government and industrial research, development and production activities acquire information for performing work assignments on DOD programs. The Phase I study covered the information needs of DOD personnel engaged in research, development, test and evaluation (RDT&E) activities.

Phase II of this study investigated the nation's defense industry to determine its information needs, and the flow of scientific and technical information (flow process) inherent in satisfying those needs. It is based on a representative sample of 1500 individuals from approximately 120,000 scientists, engineers, and technical personnel in 83 organizations in the defense industry. Sixty-three questions were asked them regarding the user of scientific and technical information, his scientific or technical task, his utilization of information centers and services, and the search and acquisition process. The analysis included compilation of frequency distributions for answers to questions and pairs of questions. In addition the qualitative data have been transformed into numerical form, and models have been specified for relationships among elements of the flow process. The models are estimated from the data by means of regression analysis, to yield significant relationships and factors within the flow process.

The Phase II Final Report describes the results of Phase II, and compares them with those of Phase I. It is presented in three volumes. Volume I contains a nontechnical summary of Phase II, including guidelines for management decisions and recommendations for the future. Volume II describes the technical approach, findings and recommendations of the study. Volume III presents the reduced data, in the form of frequency distributions and models for relationships among elements of the flow process.

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Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
User Needs						
Information Requirements						
Information Centers and Services						
Flow of Scientific and Technical Information (Flow Process)						
Structure and Numerical Description of Flow Process						
Relationships and Factors within Flow Process						
Analysis and Optimization of Flow Process						
Information Storage and Retrieval						
Defense Documentation Center						
Technical Abstract Bulletin						
Scientific and Technical Aerospace Reports						
Engineering Data						
STINFO						
Surveys						
Critical Incident Technique						
Interview Guide						
Defense Industry Population						

Security Classification