STANFORD RESEARCH INSTITUTE
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Proposal for Research
SRI No. ESU 61-78

A PRELIMINARY STUDY OF THE REQUIREMENTS, CRITERIA, AND MEASURES OF PERFORMANCE OF INFORMATION STORAGE AND RETRIEVAL SYSTEMS

Prepared for:

Office of Science Information Service
National Science Foundation
Washington, D. C.

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INTRODUCTION

Increasing amounts of money are being spent by government and commercial organizations for complex systems and equipment for the partial mechanization of the operations of collection, storage, and retrieval of scientific information. It is estimated that there is a current national annual expenditure of approximately 100 million dollars for information retrieval equipment alone. In addition to this equipment cost, a large amount of money is being spent to support special information services and centers. Undoubtedly, the main objective of these efforts is to increase the productivity of those people who must use scientific and technical knowledge to further their work. The present and projected rates of generation of scientific knowledge, and the greater reliance of all societies on progress through science, give growing importance to the making of correct choices among proposed information storage and retrieval systems.

There are no simple rules by which intelligent choices may be made among the many information systems that are pressing for attention. Many of these systems involve not only large complexes of files and information specialists, but also extremely expensive electronic equipment. In the face of a whole array of such intricate information systems, the evaluative techniques known to systems engineering and to operations research are hard pressed to select from the competing alternatives those that will most efficiently satisfy the users of scientific information within specified time and cost constraints. The problem is aggravated by the consideration that the stakes involved in the choices are likely to increase with time. This is because the information retrieval systems proposed in the future to assist the scientist will be apt to cost more than present ones; however, in return they will undoubtedly offer greater gains.

For some time, Stanford Research Institute has been interested in information processing, as well as in problems of defining and evaluating complex information handling systems. In response to a request by the National Academy of Sciences--National Research Council Ad Hoc Committee on Information Retrieval, a written informal discussion of the problems of evaluating alternative systems for information storage and retrieval was submitted by the Institute. After discussions with a member of the NAS-NRC Committee, the Office of Science Information Services of the National Science Foundation invited a formal proposal from the Institute. The purpose of the research study is to derive a preliminary set of criteria that can be applied to existing information retrieval systems in order to evaluate the performance of those systems. This proposal has been prepared in response to that NSF request.

1. How does one describe to the user who is being questioned about his needs the capabilities of economically & technically feasible and achievable systems?

2. How do accounting methods for & the economics of government & semi gov services differ from those offered on a commercial basis?

3. How are the various users in a given population to be treated — on purely an economic basis? — an estimate of importance of their work?

4. What can be learned from a study of SRI electronics people: (a) of benefit to the research (b) of use to SRI.

5. Can a model of an IR system be made that will be amenable to analytical solution or must we look to simulation for answers?

6. How well can we represent the performance of an actual system by a made-up list of performance characteristics.

7. How may test (control) questions be put to the IR system as to tests its performance

Dave Nee's experience on VAL

Statistician's background.

OBJECTIVES

There is an immediate need to make choices among the present array of systems and machines for information retrieval. The lack of sophisticated techniques by which such comparisons can be made calls for the rapid development of rough but logical measures-of-worth for candidate systems. At the same time, a need exists for the development of a longer-range research effort aimed at improving the methodology for comparison of information systems. Such research would ultimately result also in a better understanding of the role of information systems in increasing scientific productivity.

This proposal is directed primarily to the first need--namely, the fairly rapid development of rough measures-of-worth for candidate systems. Specifically, the objectives are fivefold:

(1) To develop a methodology for determining users' requirements
(2) To obtain specific data about the information requirements of a community of users.*
(3) To develop a preliminary set of criteria and a procedure that can be applied to existing information retrieval systems in order to reach tentative conclusions about the desirability of such systems.
(4) To develop measures of system performances
(5) To develop plans for a research program for the longer-range development of more basic and exhaustive criteria and methods for the assessment of alternative systems and procedures.

SCOPE AND METHOD OF APPROACH

In order to make a meaningful comparison between two or more different implementations of a given system, one needs:

(a) A Statement of Requirements
(b) A Translation of Requirements into Criteria
(c) A Means of Determining the Performance of the System
(d) A Method for Evaluating the Performance of the System

A Statement of Requirements

The first step in the establishment of requirements for a user population is a review of the findings of those who have already attempted to document such needs (see references in Appendix B). When the extent of the data available is adequately known and when the gaps in the information have been determined, discussions can begin with selected members of the user population.

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*It is later suggested that the study be restricted to the electronics field.

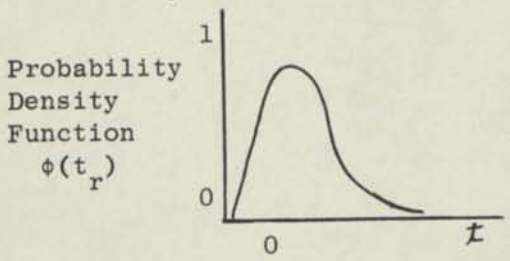
Furthermore, in order that this study yield an integrated set of results in the limited time available, attention will be restricted to a specific population of users. It is suggested that the population segment chosen be applied researchers in the field of electronics. This would permit many Institute personnel and personnel of neighboring facilities to be used as the interview subjects, thereby speeding up the study and reducing its costs. It may turn out that a fairly elaborate survey will be needed for even a reasonably accurate determination of user needs. Hopefully, initial estimates derived from interviews of carefully selected workers in this field and from the results of previous research will be suitable for this study.

Nearly all of the previous studies of users' information needs have been criticized because of certain questionable methods by which the data were obtained. This proposed research effort would attempt to derive from the critical incidents technique a general methodology for conducting studies of users' needs. A discussion of how it is hoped to use the technique is given in Appendix A. It is felt that the methodology would be applicable generally to studies of users' needs in fields other than applied research in electronics.

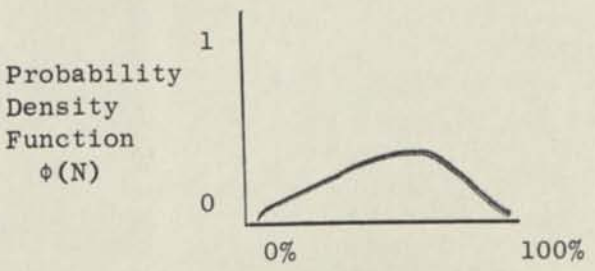
Incidentally, specific information about the users' needs in the electronics area would be a very valuable by-product of the main research effort. Since very little work has been done to describe the needs of this particular group, the information would be of direct value to all organizations that are planning equipment or information services for the electronics field.

It is almost certain that each class of user in the technical community will place a different value on each requirement (e.g., exhaustiveness of file search, speed, cost, etc.). However, each requirement that can be expressed quantitatively should not be stated as a single number. Ideally, it should be given in terms of a probability density function. However, it may be difficult as a result of this brief study to obtain sufficient data to construct such functions. Undoubtedly the use of such functions, two examples of which are shown below, rather than single numbers, should make more realistic the design or evaluation of any system to truly meet the needs of many users.

It is hoped that useful estimates can be made of the general shape of these density functions.



Required Response Time, t_r



Acceptable "Noise Level," N (% of Irrelevant Material)

It will be quite difficult to express in numerical form some of the desirable attributes of information systems. For example, a useful, quantitative description of the way in which the system or machine places demands on the user and responds to queries from the user, is not readily attainable. Nevertheless, every effort should be made to develop such a measure for these requirements.

Finally, when the full spectrum of requirements is compiled, great care must be taken to see that they are:

(a) Reasonably complete
(b) Self-Consistent
(c) Weighted as to their relative worth to the user.

An initial list of requirements, some of which can be expressed quantitatively, would include the following points.

User-Oriented Performance Parameters

Elapsed time from inquiry to partial and complete response

Type and form of final product (reference, abstract, document)

Size of file to be maintained and searched

Amount of extraneous material selected

Complexity of search logic possible (depth of analysis, syntax, role indicators, logic relationships)

Completeness of search

Amount of pertinent material neglected

Operator-Oriented Performance Parameters

Ease of man-machine communication (language, media)

Degree of compatability with other information processing systems

Ease of file maintenance (rate of acquisition and obsolescence)

Scope of subject matter covered

Ability to cope with synonyms and jargon of individual disciplines

Initial cost to the operator (equipment, installation, training, conversion, and parallel test)

Continuing cost to the operator (supplies, maintenance, operating staff)

Equipment delivery date

Expandability in size, speed, and other operating characteristics

Quality of equipment fabrication

Safety of operation

Atkinson's idea
a single index to allow inter-disciplinary communication

Flexibility (alternate input-output units, alternate coding systems, expandability into other subject areas, ability to provide multiple file copies)

Speed and effort for encoding input items

Mean time to equipment failure

Mean duration of equipment failures

Probable time to operational obsolescence

Translation of Requirements into Criteria*

From these requirements, a set of criteria, stated in system rather than user terms must be derived. Above all, these criteria should faithfully reflect the requirements without introducing any bias. Criteria, in the sense used here, are a set of self-consistent standards or tests, possibly mathematical in nature, against which the performance of an information system may be judged to see how closely it meets the requirements being placed on it. The requirements are usually stated in user-oriented terms, while the criteria are most usefully given in system-oriented terms. In particular, a single user requirement may generate a number of criteria. An example of such a situation is given in Fig. 1.

Means of Calculating System Performance

Even if complete, self-consistent, and fully-weighted criteria that adequately reflect the user's requirements are developed, there may yet be considerable difficulty in making system comparisons. This difficulty stems partially from general lack of agreement about the terms in which the performance of an information system should be described and also from the fact that it is usually not easy to calculate or express the manner in which the system actually performs in practice.

The disagreement of terms can be overcome by establishing a standard nomenclature for system functions, elements, procedures, and events. Included for definition and clarification in a standard glossary of terms would be definitions for such terms as "file items," "descriptors," "false drops," and "satisfactory search."

A strong belief in the need for simultaneous consideration of all aspects--requirements, criteria, performance, and evaluation--of the problem has already been expressed. It seems to the Institute that such an integrated approach is required for full value to be derived from work in any one of the areas. For instance, one must be able to describe

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*"Criterion" as defined by Webster and used here, means a standard, rule, or test by which a judgment can be formed.

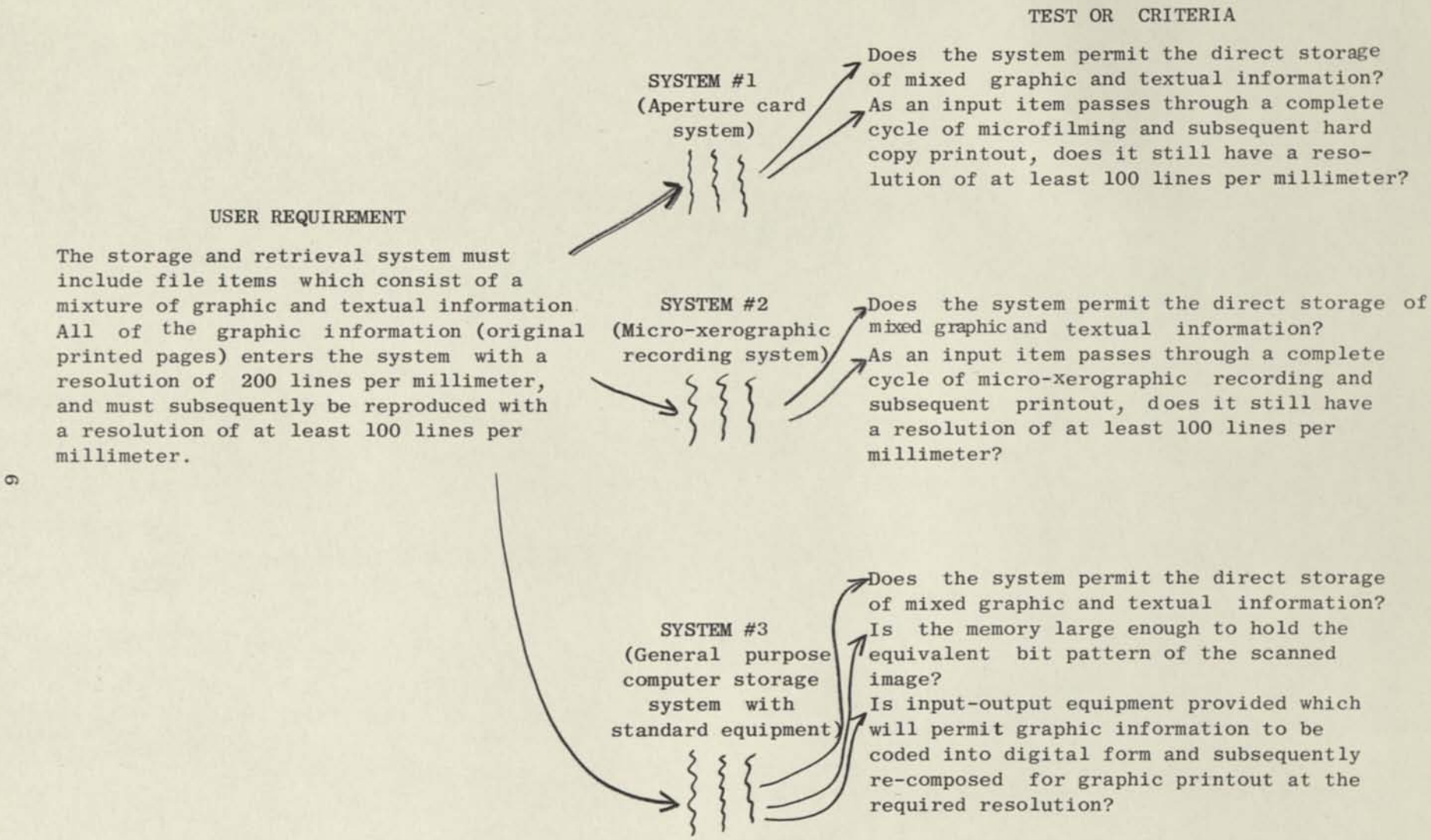

Fig. 1

An Example of Criteria Generated from a Requirement of a User

accurately and objectively to a potential user, whose needs one is seeking, the performance of achievable and economic information retrieval systems. Such a description can probably now be given with satisfactory detail and precision to permit the eliciting of users' needs. However, it is believed that a calculation of the performance accurate enough to aid the development of the evaluation techniques sought in this proposal will be more difficult.

see notes 1 & 2 & 3.

Consequently, in order that all the concommitant aspects of the problem can be treated within the scope of the project, it is proposed that a simplified but representative system be modelled and that the model's performance with various types of file material be calculated. The performance of such a system would then be used in testing the evaluation techniques evolved on the project.

See note 5 & 6.

It is felt that this approach will also point the way, in future research work, to the best manner of scientifically determining the performance of operational systems. It is expected that a combination of monitoring and simulation techniques will be called for. While the functioning of a live system can be discovered under some conditions by noting its response to test inquiries, the tests to make can probably be best determined through the study of the performance of a model of this system. Further, the investigation of other than simple models will probably best be done using simulation techniques with a digital computer.

Is this exclusively for the future ?

U.A.L. system (note 7)

Evaluation of Performance

The actual procedures to be used to discriminate between alternative retrieval systems can cover a wide range of sophistication. Ideally, a figure of merit involving as few parameters as possible should be calculated for each system, and the worth of the several systems stated in a single measure applicable to all systems. However, in practice, such schemes are not generally too useful, since considerable realism is often lost in the attempt to derive a single figure of merit. An indication of the range of sophistication for evaluation procedures is given below by several examples, given in increasing degree of complexity.

1. Screening for Simple and Obvious Limitations. A rudimentary screening test can be applied alone or as a preliminary device to eliminate systems on the basis of obviously unacceptable features, such as an exorbitant price, potential safety hazards, and estimated equipment lifetime. However, this type of test may not be able to eliminate any of the candidate systems, and in some cases, it may eliminate all systems.

2. Direct Comparison of Characteristics. One commonly used evaluation or selection technique is to construct a summary table for the comparison of the features of the candidate systems, as indicated in the sample table below.

Basic Characteristic	System - 1	System - 2	Improvement of 1 over 2
Cost	C_1	C_2	+
Speed	S_1	S_2	-
Memory Size	M_1	M_2	+
.	.	.	.
.	.	.	.

However, unless each of the basic characteristics has a relative weighting, there will not be any means for directly comparing one alternative system against another. And in any case, none of the candidates have been matched against the needs or requirements of the user. That is, the machine characteristics are compared without any consideration of the characteristics that are actually required.

3. Comparison with Minimum Requirements. One simple way to incorporate the users' requirements with the alternative machine characteristics is to compare each machine characteristic against minimum scalar requirements that have been established by the users. An example of such a comparison is shown in the table below.

Minimum Users' Requirements (Scalar)	System - 1	System - 2
Cost: xxx	Meets	Does not meet
Speed: yyy	Meets	Meets
Size: zzz	Does not meet	Meets
.	.	.
.	.	.

After such a table has been completed, it is not always clear how the results should be used. For example, what happens when each alternative system meets the same number of, but different, criteria? This type of analysis also suggests a need for ranking the users' requirements.

Ranking of Req's.

4. Comparison on a Weighted Probabilistic Basis. There are undoubtedly many other procedures that can be used to evaluate alternative systems. One example of a procedure that provides a greater degree of refinement of evaluation is the use of probabilistic expressions to describe the requirements and characteristics, and appropriate weighting functions to rank each of the requirements by their relative value or importance. Such a procedure can be illustrated with a tabulation such as the one shown in Table I. In this example,

probability density functions such as the ones previously outlined are described where possible for each of the requirements and each of the machine characteristics. An expression giving the degree of conformity between the requirement and the characteristic will be obtained when the corresponding density functions are compared. This performance number or degree of satisfaction can be computed for each characteristic of each candidate system. A separate weighting function for each requirement can then be used to weight the initial performance number according to its importance in the over-all system operation.

These are but a few of the many possibilities that exist. The proposed research effort will be directed to the development of a number of the more accurate and comprehensive evaluation techniques, such as the weighted probabilistic comparison described above. The evaluation operation can also serve usefully as a design tool by suggesting modifications to the systems or to the weighting of requirements. Thus, an iterative design cycle would use the information from the evaluation to modify the system weighting of requirements and criteria.

Fadback

The requirements, criteria, and evaluation procedures developed during this study will be tested on two or more representative information retrieval systems to point out the problem areas in the procedures and to point out those aspects which need further study. The final result of this effort will be a completed list of requirements, criteria, and evaluation procedures which can be used for preliminary examinations of information retrieval systems. As a final task, the study would also provide more specific plans for continued study and the development of improved techniques for the evaluation of complex information retrieval systems.

Next project.

Specific Project Tasks

In summary, there are a number of specific tasks that must be undertaken as part of this proposed research program. The project team would perform the following tasks.

selection of important ones.

Task 1 Develop an initial list of users' requirements to be studied.

metric

Task 2 Develop scalar and probabilistic measures of as many of the requirements as possible within the level of effort of this study.

ranking

Task 3 Develop the ranking or relative weighting for as many of the requirements as possible within the level of effort of this study.

criteria & comparison techniques

Task 4 Develop a rough set of criteria and a procedure, that could be applied to existing systems in order to reach tentative conclusions about their performance.

Construct benchmark problems?


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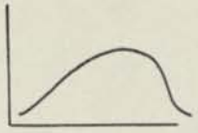
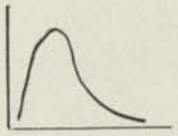
Minimum Users Requirements (Probabilistic)	Degree of Satisfaction of Requirement*		Relative Weighting Function for Importance of Requirement	Weighted Performance Number	
	System 1	System 2		System 1	System 2
Search Speed: $\Phi(S)$ 	1.0	0.6	W_1	$1.0W_1$	$0.6W_1$
Max. File Size: $\Phi(M)$ 	0.5	0.7	W_2	$0.5W_2$	$0.7W_2$
-----	--	--	--	--	--
-----	--	--	--	--	--
				Total	Total

*Based on comparison of the probability density functions of the requirement and the system. performance

TABLE I

Weighted Probabilistic Comparisons

Task 5 Develop a model of a representative simple information retrieval system.

Task 6 Test the requirements, criteria, and evaluation procedures on such representative systems.

Task 7 Develop plans for a research study to better describe the users' requirements, and to improve the criteria and evaluation procedures.

REPORTING SCHEDULE

The primary results of the research program will be presented in a final report at the conclusion of the project. In addition, both oral and written progress reports will be prepared at regularly scheduled intervals, or whenever a specific need arises.

PUBLICATIONS

SRI encourages technical publications by its professional staff, whenever such publication does not endanger security or the proprietary rights of sponsors. The Institute requests the right to publish significant results of this research work as soon as necessary patent protection has been obtained.

ESTIMATED TIME AND CHARGES

This research program would be conducted over a period of six months at an estimated cost of $39,023. This amount would not be exceeded without prior approval of the client. A breakdown of charges is provided at the end of this proposal.

CONTRACT FORM

It is requested that any contract resulting from this proposal be written on a cost-plus-fixed-fee basis.

ACCEPTANCE PERIOD

This proposal will remain in effect until 1 July 1961. If consideration of the proposal requires a longer period, the Institute will be glad to consider a request for an extension of time. The work could begin within two weeks after the formal acceptance of this proposal.

PROJECT AUTHORIZATION

This proposal can be established as a project on the basis of a letter of acceptance or by returning two signed copies of the enclosed research agreement, with any modifications that may be agreeable to both parties.

SRI QUALIFICATIONS AND INTEREST

There is wide interest among many staff members at the Institute in the problem of the collection, storage, retrieval, and use of scientific information. These men and others on the staff are qualified to help in a concerted attack on this problem by virtue of the fact that they have experience in many of its facets and because they are involved with the subject in their daily work.

As systems engineers, information retrieval experts, statisticians, behavioral scientists, computer engineers, and operations researchers, the Institute staff has worked on a fairly wide range of problems in the information retrieval field or in areas directly related to it. Many Institute projects involve the evaluation and comparison of complex information handling systems and, consequently, there exists at SRI both the appreciation of the difficulties of making valid comparisons and a keen intellectual interest in the subject.

QUALIFICATIONS OF PERSONNEL

Personnel for this study will be chosen from those whose biographies are listed below. Others may be brought in as the work demands.

Bourne, Charles P. - Research Engineer, General Systems Department

Mr. Bourne received a B.S. degree in Electrical Engineering from the University of California in 1957. He is working on an M.S. degree in Industrial Engineering at Stanford University, specializing in data-processing and operations research.

He served in the U.S. Marine Corps during 1950-1951. In 1952-1953 he was an Instructor at Convair Guided Missile Division. While he was a university student he did summer work as an Engineering Aide at Stanford Research Institute on design studies for the ERMA computer system.

In June 1957 Mr. Bourne became a Research Engineer on the staff of the Institute. He has participated in a government project to investigate storage, retrieval, and reproduction techniques for a file of several million engineering drawings; engineering and operational evaluations of several new general-purpose digital computer systems for various computer manufacturers; technical planning for digital computer system installations; and a government project to design a comprehensive mechanized system for accumulating, reviewing, disseminating, storing, and retrieving abstracts of European technical literature. He also supervised the operation and programming effort and conducted the systems studies that determined programming requirements, choice of computer, and expansion capabilities for a large digital computer system currently used as part of a military reconnaissance system. He has provided product planning assistance in the design of magnetic tape systems for commercial data processing equipment and market research and product planning for commercial information retrieval equipment, and has conducted system

studies for the design of a very large memory for information retrieval problems. He has provided technical assistance in the design of the data processing and display portions of a world-wide bomb damage assessment center for the joint military services, and has also assisted in the evaluation of the data processing and display portions of a large air defense system. He is currently working on pattern recognition and the processing of graphic information with digital computer techniques, as well as methods for automatically abbreviating and coding English text material.

Mr. Bourne has written several articles for technical journals, dealing with information retrieval and technical information problems. He is a member of the Institute of Radio Engineers, the American Documentation Institute, the National Microfilm Association, and the Association for Computing Machinery, and was Chairman of the Sessions on Information Retrieval and Machine Translation at the 1959 Western Joint Computer Conference, the 1960 Annual Conference of the American Documentation Institute, and the 1961 Annual Conference of the Society of Technical Writers and Publishers.

Kincaid, Harry V. - Manager, Behavioral Sciences Program

As manager of the Behavioral Sciences Research Program, Dr. Kincaid is responsible administratively for research in experimental psychology, sociology, social psychology, anthropology, and educational psychology. These sciences are applied to such problems as man-machine systems, consumer behavior, surveys of attitudes and opinions, and personnel selection, training, and evaluation

Before joining the Institute staff in January 1956, Dr. Kincaid served for three years as a research associate in the Bureau of Applied Social Research, Columbia University. From 1951 to 1953, he was an assistant study director, Survey Research Facility, Stanford University. His earlier background includes Air Force service during World War II and various teaching and research assignments while pursuing graduate studies.

Dr. Kincaid received a B.A. degree in psychology from the University of California in 1947 and M.A. and Ph.D. degress in sociology from Stanford University in 1949 and 1953.

Dr. Kincaid's published works include a monograph written in conjunction with Fred Ikle, Some Social Aspects of Wartime Evacuation of American Cities (Washington: National Academy of Science, National Research Council, 1953), and articles in professional journals. He was a John Randolph and Dora Haynes Foundation research fellow in 1950-51, and is a member of the American Marketing Association, American Sociological Society, and American Association for Public Opinion Research.

Lefkowitz, Benjamin, - Operations Analyst, Industrial Operations Research and Electronic Data Processing

Mr. Lefkowitz specializes in the study of electronic data processing systems for application to industrial operations. He performs analyses in the fields of transportation, distribution, warehousing, product mixing, inventory control, and system simulation.

Projects in which he has participated are: (1) a study of the utility of an electronic data processing system for a major oil company, (2) gasoline blending procedure for a major oil company, (3) stock control policy for a supply office of the U.S. Navy, (4) computer simulation of a complex logistic system for the U.S. Air Force, (5) design of an information storage and retrieval system for the U.S. Air Force, (6) design of an information system for controlling R&D activities for the U.S. Army, and (7) development of a method for computing minimum distance routes for an agency of the State of California.

Mr. Lefkowitz was an applied sciences representative for International Business Machines at the time he joined the Institute staff in 1956. Formerly, he was a research assistant at Stanford University, statistician for the Econometric Institute in New York City, and statistical analyst for another New York firm. He served as an officer in the Navy during 1952-1955, handling classified information.

A graduate of City College of New York with a bachelor's degree cum laude in statistics and mathematics, Mr. Lefkowitz continued his education at Stanford University where he received a master's degree in statistics and mathematics. He also did some graduate work at American University in Washington, D.C., while in the Navy, and at UCLA following his release from active duty.

Mr. Lefkowitz is a member of the Econometric Society and the Association for Computing Machinery.

Sorensen, Philip H. - Psychologist, Behavioral Sciences Research Program

Dr. Sorensen directs research on personnel and educational problems. Typical studies include personnel policies for The Ford Foundation's overseas staff; the future of a San Francisco Bay area hospital's school of nursing; a training manual on operational implications of radioactive fallout for the Air Force; the future development of Mills College, Oakland, California; a survey of flight crews' working conditions for a major airline; an analysis of trends in supply and demand for scientific and engineering manpower; a critical review of "teaching machines"; and an evaluation of education and training activities for an airline.

For one year, Dr. Sorensen was a member of the Institute's project team at the Army's Combat Development Experimentation Center, Fort Ord, California, where he worked on studies concerned with weapons system performance, surveillance, and intelligence production, and logistics. He continues to participate in CDEC work on a task basis.

Before coming to the Institute in 1956, Dr. Sorensen spent two years as a student personnel adviser in Portland, Oregon, public schools; two years as a counselor at Washington State University; and three years as assistant dean of students at Kansas State College. He served three years in the Navy during World War II, and currently holds the rank of lieutenant commander in the Naval Reserve.

Dr. Sorensen received a B.A. degree with distinction, in social science and an M.A. degree in educational psychology, both from Washington State University, and a Ph.D. degree in educational psychology from Stanford University. He has also attended Willamette University, the University of Oregon, Reed College, and Kansas State College. He is a member of Phi Beta Kappa, Phi Delta Kappa, and the American Psychological Association. He has published articles in Psychological Reports and the American Psychologist.

Whitby, Oliver W. - Manager, General Systems Department

Dr. Whitby received a B.Eng. degree from McGill University in 1938. In 1940 he received an S.M. degree and in 1949 an S.D. degree, both in Communication Engineering from Harvard University.

In 1949 Dr. Whitby joined the staff of the Engineering Division of Stanford Research Institute. From 1950 until 1955 he was responsible for the broad system planning for the ERMA automatic bookkeeping system developed at the Institute for the Bank of America. In 1955 he headed a group charged with doing technical program planning for the Computer and for the Control System Laboratories of the Engineering Division. In 1956 he became Manager of the General Systems Department, carrying out systems engineering for problems that employ computers, communication networks, and control elements.

In this capacity he has been responsible for the close technical direction of projects in the following areas: automatic airline reservation systems, banking automation, information retrieval system design, battlefield instrumentation, and communication network research. He is an active member of the group within the Institute that has maintained a long-term interest in Air Navigation and Traffic Control (ANTC). In this role he has maintained close contact with the FAA and with various air carriers flying the North Atlantic. He has participated in the preparation of many technical proposals on ANTC problems submitted to these organizations.

Dr. Whitby is a Senior Member of the Institute of Radio Engineers, and an associate member of the Operations Research Society of America. In 1954-55 he was the IRE representative on the Joint Computer Conference Committee and in 1955 was General Manager of the Western Joint Computer Conference.

Appendix A

Notes on User Requirements

In any study to develop criteria for the performance of information storage and retrieval systems, it is axiomatic that the requirements of the user must be taken into account. This has not gone unnoticed in previous studies of information systems. However, it is difficult to determine with accuracy the requirements of any given segment of the user population. The requirements are likely to vary by the type of activity, research habits of the scientist, the particular use to which the information is to be put, and the like. In addition, one must ensure that those scientists who are observed or asked questions with a view to estimating their information requirements are qualified to comment on that problem. Perhaps one of the biggest areas of confusion is the lack of a clear distinction between user requirements and user action. The scientist may not be aware of his ultimate requirements, since he may not know the full range of information systems currently available to him, or that could be made available to him given the state of the art. Thus, a study of what he actually does, will not necessarily lead to what should be. These difficulties notwithstanding, it appears that the requirements of the user are one of the prime determinants of the design of information systems.

There is a substantial literature on the information requirements of scientists of which much undoubtedly is of value for this study, although there has been much criticism of the entire "user need" approach. In any event, a preliminary effort such as the one proposed here cannot hope to supply definitive results on user requirements. The approach to be used here will, therefore, be oriented to two major aspects of the problem: (a) knowledge of user requirements sufficient to proceed with the development of the model for evaluating information systems; (b) methodological work leading to more refined measurements of user requirements for the future.

To be of maximum usefulness, in this context, the study of users will be geared to the problem of "critical" requirements, i.e., those requirements for information that are fundamental to the solution of a given scientific or technical problem. In any scientific enterprise there are crucial stages. Some of these stages require scientific information and some do not. The objective would be to determine, insofar as is possible, a list of critical information requirements along with an estimate of how adequately these requirements are being met, using applied electronics research as a vehicle for study.

The method of approach would employ a modification of the well-known critical incident technique as suggested by Flanagan (see references in Appendix B). This technique is based on the idea that any human endeavor is composed of many parts, some of which are "critical" to the success of the endeavor and some of which are not. In science and technology, the same is presumed to be true.

Listed below are the steps that would be taken:

1. A systematic definition of "applied electronics" research, including the precise subject matter and personnel involved.

2. A statement of the types of functional activity phases taking place in electronics research (see Fig. 2) such as:

   a. Definition of problem

   b. Formulation of research design

   c. Methods and techniques

   d. Supporting evidence

   e. Theory and conceptualization

   f. etc.

3. Enumeration of the critical incidents in each of these functional categories. The incidents would be subdivided into those requiring scientific or technical information and those not requiring such information. The data would be collected primarily by personal interviews. However, it may be possible to employ diaries, observation, and experimentation to a limited extent.

4. Analysis of the critical incidents with specific reference to evaluating the performance of competing information systems.

The end product would be a list of those information requirements found to be crucial to success in the various functional stages noted above. "Criticality" of information requirements will no doubt vary according to the habits, pre-dispositions, creativity, and attitudes of individual scientists. Part of the logic of the critical incident technique is that observations of sufficient individuals will reveal areas of common agreement, which serves as one index of the criticality.

Since this is a modest effort, definitive results are not expected. However, it is anticipated that progress will be sufficient to provide adequate inputs to the evaluation system as a whole, as well as providing guidelines for more intensive studies of user requirements in the future.

The study will be based fully on the available literature in the area of user requirement, particularly as outlined in the proceedings of the 1958 International Conference on Scientific Information, and in Herbert Menzel's monograph, "Review of Studies in the Flow of Information Among Scientists." (See references in Appendix B.)

CRITICAL INFORMATION REQUIREMENTS

FUNCTIONAL ACTIVITY	Review Articles	Abstracts and Indexes	Foreign Language Literature	Face-to-Face Talk with Experts	Meetings and Seminars	Journals and Books	Others
Definition of Problem							
Formulation of Research Design							
Methods and Techniques							
Supporting Evidence							
Theory and Conceptualization							
. . .							

Fig. 2

CRITICAL INFORMATION REQUIREMENT MATRIX

NSF

ESTIMATE OF TIME AND CHARGES

Personnel Costs

Supervisory, 1 man-month at $2,050/mo.	$ 2,050	
Senior Professional, 1-1/2 man-month at $1,350/mo.	2,362	
Professional, 1-1/2 man-month at $805/mo.	1,208	
Professional, 1-1/2 man-month at $635/mo.	952	
Professional, 1-1/2 man-month at $1,335/mo.	2,003	
Professional, 6 man-months at $980/mo.	5,880	
Technical, 1/2 man-month at $700/mo.	350	
Clerical, 3 man-months at $460/mo.	1,380	
*Total Personnel Costs		$ 16,151
**Overhead at 100% of Direct Salaries		16,151

Direct Costs

Travel and subsistence (6 trips to Washington)	2,715	
Shipping and Communications	150	
Publication of Reports	1,650	
Total Direct Costs		4,515
Total Estimated Costs		$ 36,815
Fixed Fee at 6% Estimated Cost		2,208
Total Estimated Costs Plus Fixed Fee		$ 39,023

---

*Included in direct labor are all salary base costs such as vacation, holiday and sick leave pay, social security taxes, and contributions to employee benefit plans.

**The overhead rate quoted represents current cost experience. It is requested that the contract provide for reimbursement at this rate on a provisional basis, subject to retroactive adjustment to fixed rates negotiated on the basis of historical cost data in accordance with ASPR 3-704. The contract should also specifically provide for the inclusion of general research costs as an allowable indirect expense to the extent determined reasonable. It is further requested that any contract resulting from this proposal provide for the determination of costs in accordance with ASPR, Chapter XV, Part 2, Rev. 50.

GSD 24.2 K = total CB + 11. K

Kinnaird 10.4 K

Lefkowitz 4.3 K

November 14, 1961

Mrs. Helen Brownson
Program Director for Documentation Research
Office of Science Information Service
National Science Foundation
Washington 25, D. C.

Dear Helen:

This short note describes in summary form the work on our project to date. I think that this brief description will be adequate for the NAS-NRC ad hoc Committee meeting, but if you desire more information, I would be glad to furnish it.

DETERMINATION OF USERS' REQUIREMENTS

The personal interviews have been completed, after talking with 92 electrical engineers from 4 organizations, and 11 metallurgists from 2 organizations. Most of the data has been processed and analyzed, and all of the information will be included in the final report. It was found that some requirements could be measured in a quantitative manner, and that rankings could be determined for the relative importance of each of the requirements. It was also found that in several cases, different organizations or groups of users could not agree amongst themselves as to the relative importance of the requirements. As indicated, the interviews were made primarily with the electrical engineers. However, the same procedure was also used with 11 metallurgists to see if the methodology was relatively independent of the subject specialty of the user population. Within the limits of this small test, it was found that our methodology could be universally applied without major modification, to users in different subject fields. Some errors and oversights have been found in the interview guide, and many additional improvements have come to mind. The final report will include a critique of our interview guide, and suggestions on how a subsequent guide might be improved.

EVALUATION TECHNIQUES

Three separate and complementary tools have been developed for the evaluation of proposed retrieval systems: (1) a coarse screening procedure; (2) a performance evaluation procedure; (3) a cost analysis and simulation procedure.

The coarse screening procedure provides some background information on ranges of retrieval requirements and parameters that exist today in many operational information services. This information will permit some statements to be made as to the degree of universality of proposed systems. The attached figure describes, for example, the storage capacity and input rates required of any complex of equipment that claims to solve the problems of all college and university libraries.

The performance evaluation procedure, as illustrated by the attached preliminary worksheet, takes each requirement and measures the amount of agreement between the users' needs and a particular system's performance. This measure of agreement is then weighted by what the users' felt was the relative importance of that requirement. This sequence of computation is described on the worksheet as a single horizontal line across the page. All of the weighted agreement numbers are then summed to give a total measure of how well a particular system satisfies the requirements of a specific population of users. A separate worksheet would be computed for each system under consideration. The sample worksheet shows the form of our measurements of users' requirements, as well as hypothetical performance figures for a specific retrieval installation. The requirements are ranked in the order of importance (the top one is the most important) as determined by the users interviewed in this study. The evaluation methodology is reasonably complete. However, there are several reasons why it would be of very limited value for immediate use for the field of metallurgy:

1. The method requires quantitative information and measurements of each of the requirements of the specific population of users to be served. The requirements of the metallurgists or users of the metallurgical information services have not been measured in this way, and there is no evidence at this time to suggest that the measurements of the electrical engineers could be used instead. A separate program of measurement for this specific population should be initiated.

2. No measurements have been made of the relative importance of each of the requirements to the metallurgist population. As with the specific requirements, these weighting factors should be determined from a study of the metallurgist population.

3. Very little performance data is available for existing or proposed systems that is of the form and type required for the evaluation procedure. More specific measurements or estimates must be obtained from the manufacturers and proponents of alternative systems.

Because of the lack of specific performance data, it is unlikely that any test systems will be evaluated by this procedure during this current project.

A cost analysis and simulation procedure has been programmed and run on a computer. This program accepts a definition and functional description of a storage and retrieval system; considers the limitations of all the personnel and equipment employed; allows variations in the salary, burden, and overhead structures; allows variations in the methods of amortizing the equipment cost; allows variations in file size, accession rate, and the number of search requests--and

from this information, computes an equivalent annual operating cost for that system. The attached illustration describes the result of applying this analysis procedure to two distinctly different retrieval systems over a wide range in the number of searches and accession rate. The two hypothetical systems chosen were a manual edge-notched card system and a computer system. The attached illustration shows the costs of operating each of the systems over a wide range of operating conditions. These preliminary curves are illustrated as smooth planes, However, they are actually piecewise-linear monotonic increasing planes, whose interior surfaces have, for simplicity, been approximated on this illustration. Naturally, the accuracy of the analysis procedure depends to a large measure on the basic time and cost factors for each of the functional components of the proposed system. Very little of this type of data is available, and it would be very helpful if some studies were conducted to derive or obtain this information. Incidentally, the program was written in ALGOL, a universal programming language that can be run on a number of different computer models. For that reason, it will be possible for other organizations to use our programs.

SUGGESTIONS FOR ADDITIONAL RESEARCH

There appear to be several topics that would be fruitful targets for continued research. At this time, the following tasks are pertinent:

1. An operations analysis study of several operating systems to develop realistic time and cost factors for the basic functional elements. This would permit a more accurate cost analysis and simulation of proposed systems or extensions of existing systems.

2. Additional development and refinement of the simulation and cost analysis programs, with test evaluations of a number of different retrieval systems.

3. Additional development of the coarse screening criteria and performance evaluation methodology, measurement of the performance of a few existing or proposed systems, and application of the evaluation procedure to a few test cases.

4. Additional development of the methodology of measuring users' requirements--concentrating on the requirements that were not measured during the current study. This work should be coupled to another measurement of a specific population of users, perhaps the metallurgists.

5. Study of some of the more basic considerations of the evaluation procedure, such as the possibility of converting all of the user requirements and system performance characteristics into a uniform basis for comparison, such as <u>time</u> or <u>cost</u>. Another basic question is that of determining how the users' productivity is related to the amount of information services provided, (i.e., what gain in user productivity results from increasing incremental amounts of information?).

REPORTS

The final written report will be delivered by the end of December 1961.

I hope that this brief report will satisfy the needs of the Committee for its forthcoming meeting.

Sincerely,

Charles P. Bourne
Research Engineer
Systems Engineering Department

CPB/se

Attachments

2101 CONSTITUTION AVENUE
WASHINGTON 25, D. C.

TELEPHONE
EXECUTIVE 3-8100

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE, WASHINGTON 25, D. C.

OFFICE OF DOCUMENTATION

AGENDA

MEETING OF THE AD HOC STEERING COMMITTEE, W.R.U. PROJECT
TUESDAY APRIL 17, 1962 - 10:00 A.M.
HOTEL MANGER, EAST 13th at CHESTER AVE., CLEVELAND 14, OHIO
(Room will be reserved in name of National Academy of Sciences)

Open meeting, beginning 10:00 a.m.

10-10:15 a.m.	Opening by Dr. Marzke
10:15-11:15 a.m.	Report of Charles P. Bourne, Stanford Research Institute
11:15 a.m.-12:15 p.m.	Report of David B. Hertz, Arthur Andersen & Co.
12:15-12:45 p.m.	Discussion
12:45-2:30 p.m.	Lunch*
2:30-2:45 p.m.	Progress Report by Bureau of Social Science Research, Inc. on their contract with NSF
2:45-3:00 p.m.	Comments by A.S.M.
3:00-3:15 p.m.	Comments by WRU Center
3:15 p.m.	Adjournment of Open Meeting

Closed meeting - Ad Hoc Committee, beginning at 3:15 p.m.

3:15 p.m.	Report by Newman a) Preliminary notes on parallel search results b) Final Report 1. Content 2. Timing
3:30-3:45 p.m.	Discussion

3:45 p.m. till adjournment	Comments of Members

* Those who have not already accepted, please let me know by April 12 so that I can arrange for lunch for you.

Simon M. Newman
For the Committee

ASM Current awareness $50/mo. + 10 cents/abstract obtained } now have 47 customers

semi monthly

---

retrospective $200/year of publication + 10 cents/abstract } 122 searches already during 1961

$550/cumulative file +

to search
Cost/publ. year
200
200

} the entire file can be searched for 550. +10.

publ. year 61
60
59
58

Answer Rec
File —

TO: NSF (Project File) 3741-1

FROM: Charles Bourne

SUBJECT: General Methods for Determining User's Information Requirements

---

There are a number of different approaches which can be taken to determine user's information requirements. Generally, the approaches might be characterized by one of the following situations: (1) a look at the user's information environment; (2) a close look at the information resources and facilities. (This is a special part of the information environment). (3) a close look at the user; Methods and considerations appropriate to each of these approaches are discussed below.

A Look at the User's Information Environment

This approach examines some of the economic and social pressures present in the working scientists environment. These pressures or practical constraints put some limits on the information resources which can be utilized by the individual. For example, regardless of the type of information or services available, an individual or organization still has a limited amount of time or money to spend for information. For this reason, it would be of interest to note what some of the present constraints are, since they are not likely to change very significantly as new and improved information retrieval systems are provided. To do this, we might ask some of the following kinds of questions.

1. How much do organizations spend now for information services (and how much do they feel they can afford?)

2. What is the amount of time that a worker can afford (because of cost or personal pressures) to spend in reviewing or searching the literature?

3. What total volume of literature is currently made available to him in his own organization? This represents the organizations scope of interest, and budget for information services.

4. What total volume of literature is of personal interest to the worker? This represents the parameters of the file which satisfies a good fraction of the information retrieval needs of the individual worker.

A Look at the Present Information Resources

The present level of service of the user's information resources provides a lower bound for the requirements of any proposed alternative systems. That is, any new retrieval system should provide at least as much service and value as the present systems. There is the further consideration that the present actions of the user reflect, in some unknown degree, the needs and requirements of the users. Withthis in mind, we might consider the following topics.

1. What are the ways in which the libraries and information services are actually used (what functions, what type of material, what type of user, what type of questions)?

2. What are the operating statistics of the present systems (what volume of questions, how many users, what budgets, what type of staffing, what file size, what input rate)?

A Look at the User

Fundamentally, the information about the user is the data that we're trying to obtain--but unfortunately it is also the most difficult to obtain. Measurements are difficult if not impossible, and most studies resort to judgements or opinions. The user himself is often a poor source for direct comments on his needs because he is usually influenced by the tools and facilities that he is familiar with, and cannot discriminate between his actual needs, and his actual way of doing business. Any of the following methods, or combinations of them, might be used to obtain information about the user's requirements.

1. Ask the user specific questions about what they think their requirements are (e.g. tolerable delay, form of resulting product, types of service preferred).

2. Perform an autopsy of a recent information request by a user. Probe the circumstances that motivated the request for information. Determine what parameters such as response and error rates would have been tolerable in this particular situation. Find out the nature of any disappointments or unsatisfactory results. Taking advantage of the user's hindsight, find out what he would liked to have obtained in the way of specific products or services.

3. Monitor the establishment and fulfillment of a research project or experiment, and monitor the specific needs and requirements as they occur. Some realistic data may be obtained in this way, but the method also has the disadvantages of interferring with the working group, requiring a relatively ~~lag~~ long

time for completion of the data gathering through a complete project schedule, and probably requires a relatively large amount of observer's time for a number of different projects in order to obtain statistically significant data.

4. Postulate a "perfect" retrieval system and then invite questions about the system, allow people to pose questions to the system, and invite requests for service from the system.

5. Determine what the functions of the various portions or channels of the information services are (e.g. preparation to learn new techniques, to learn experimental results, to plan new research, to prepare lectures, to keep abreast, etc.) and find out how well each of these functions is being met. The dual of this method is to find out what the various portions or channels of the information system are (e.g. abstracts, books, journals, advertisements, etc.) and find out what functions each of these channels serve.

6. As an indication of the amount of improvement that might be possible, measure the performance that a user usually obtains (let him perform or direct a test search), and compare it to the performance that can be achieved (by an exhaustive search of all available resources).

7. In order to determine the point of diminishing returns by providing information services, perform a controlled experiment in which identical or comparable tasks are performed by groups which are provided with different amounts of information resources.

8. In order to estimate the scope of interest or range of coverage of the individual user, record, in some uniform measure, the amount of information that is normally clustered about the individual in his own office. How large a file of information for personal immediate use does he consider to be important enough to warrant regarding personal time and money on their acquisition?

9. What are the circumstances surrounding the critical requirements for information? That is, those requests or requirements for information that are critical or fundamental to the solution of a given technical problem?

Board (orig + 2 + 1 blue)

TO: NSF Project 3741-1 File

FROM: Charles Bourne

SUBJECT: ~~Meeting~~ with ~~Vinsen~~ Benson - Lehner Corporation, Santa Monica (14 July 1961)

~~Vinsen~~ Benson was glad to hear that we were doing this work and was anxious to cooperate in every way possible. During our discussions, we were able to generate the following list of requirements that we felt were important in information retrieval system:

(COPY 1 to 14 FROM LIST)

~~Vinsen~~ Benson and Gunther Krumbach furnished a detailed description of an advanced information retrieval system (Comac - 2) that they hope to demonstrate by December, 1961, They would like to see this unit subjected to our evaluation procedure as part of this project. Documentation Incorporated in Washington (Mr. Eugene Miller, President, Mr. Mortimer Taub, Board Chairman; Mr. Al Greithen; Mr. Eugene Walk; Mr. John Sayre) will furnish detailed information about the software for Comac 2, as well as information about their operating experience with the current Comac which they developed and originally licensed to IBM.

~~Vinsen~~ Benson-Lehner's R&D group ~~is~~ has approximately 20-25 people in it including perhaps 5 applied electronics researchers. ~~Vinsen~~ Benson volunteered that these people could be used for test subjects if we desire.

For Charles Bourne

1) Size of store

2) Growth rate

3) Size of sub-groups in store

4) Number of descriptors for indexing

5) Number of descriptors for searching

6) Information content of answer, alphanumeric, graphic, size, etc.

7) Urgency of reply

8) Value of reply

9) Value of completeness of answer

10) Value of accuracy of answer

11) Probability of absent document

12) Significance of absent document

13) Penalty of misfiling with nonmechanized system

14) Value of interchange of blocks of information with other stores

notes of meeting with Bernard Benson & Chas Bourne

1) questionnaire
2) Western Reserve.
3) non-conventional IR systems

Annex Rca
File

TO: NSF Project 3741-1 File

FROM: Charles Bourne

SUBJECT: Visit to National Science Foundation (July 17 and 19, 1961)

I talked with Helen Brownson and Simon Newman to describe our progress to date and to explain the things that we hope to achieve during the next 6 months. We reviewed in detail the approach and the accomplishments in each of the specific project tasks. Mrs. Brownson was unable to tell us of any other work done on questionnaire or usage studies subsequent to the summary report that had been written by Menzell. However, she did provide some rough draft descriptions of the characteristics of a number of non-conventional information retrieval systems from data currently being collected for an NSF publication on this topic. She also provided references to several other projects which are of mutual interest to this one. She did mention that Arthur G. Anderson, another contractor in the East, is also working for NSF on this problem at a level of effort less than ours and also for 6 months. Their principal investigator is a chap by the name of Wentz who is apparently known for some work in group dynamics.

Brownson posed the problem of the Bureau of Budget clearance on questionnaire surveys before I could introduce the subject. (This is a restriction by the Bureau of Budget which says that they must authorize or provide clearance for any government-sponsored surveys which have over 5 respondents.) This means that any written questionnaires administered to a group of more than 5 people will require advance

clearance by the Bureau of Budget. This is apparently a cumbersome procedure and it takes quite a bit of time. Also, the Bureau is known to slow down quite a bit when asked to speed things up. It looked like one way we could get out of this problem, considering the extreme time schedule that we have for this project, is to consider each of the questionnaires to be an outline guide for the interviewer and let the interviewer fill in the answers on the questionnaire.

Brownson didn't see any particular reason why we should concentrate especially on the Western Reserve System. It was her feeling that we could make the study rather general in nature. However, she did want to see more emphasis on evaluation of different intellectual organizations; that is, different classification and indexing systems rather than concentrating our effort on evaluating equipment or hardware or ways to implement the intellectual arrangements.

TO: NSF Project File DATE: June 26, 1961

FROM: Charles Bourne

SUBJECT: Notes of Meeting with Kincaid & Peterson (June 23, 1961)

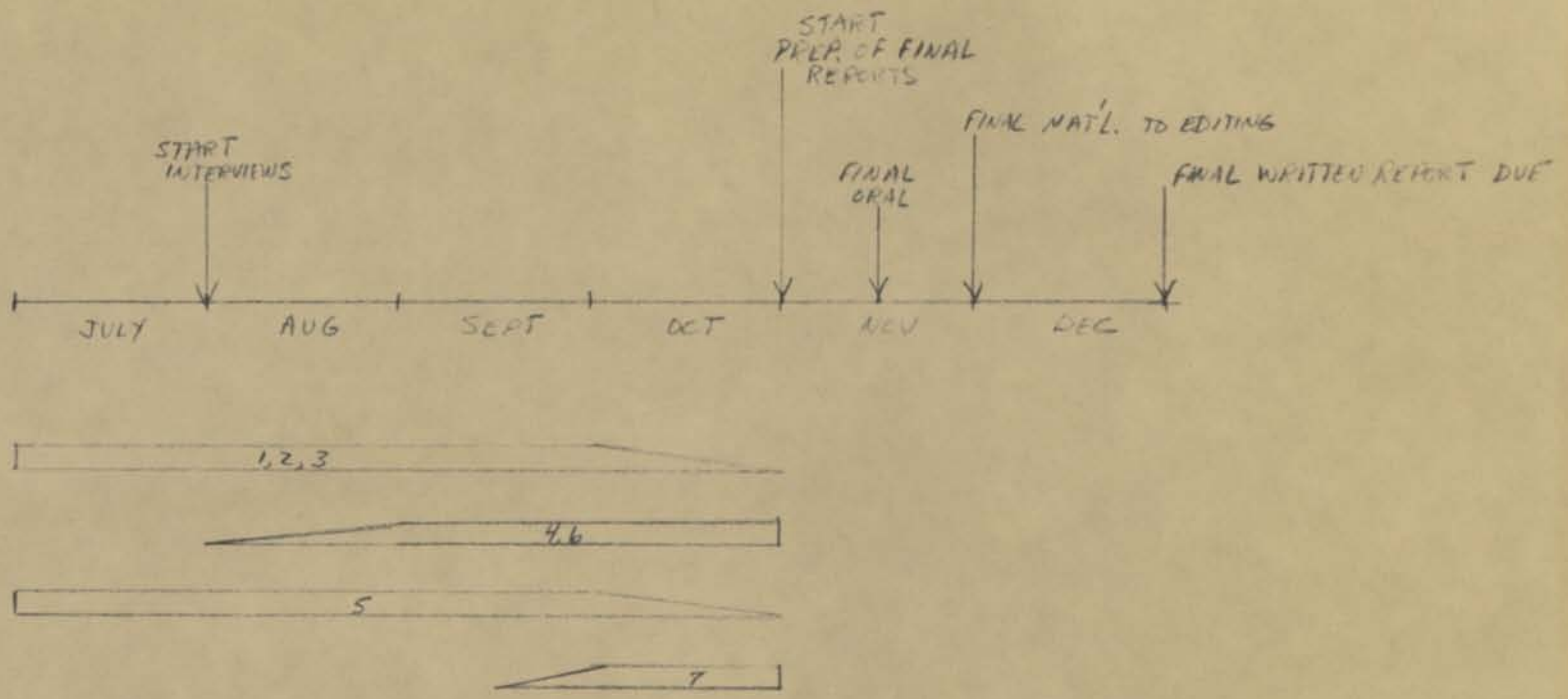
1. The sample population is to be drawn entirely from the SRI staff if possible, and will include applied electronics researchers from all fields (e.g. microwave, computers)--thus yielding a cross-cut or composite sample, rather than a detailed study of a particular discipline, age group or academic level. Jim Norton is currently having a list of SRI E.E.'s compiled for this purpose.

2. A tentative project schedule is attached to indicate the relative sequencing and overlap of the major work tasks. The seven numbered tasks are the major tasks of the project as outlined in the proposal. Initially, it would appear that (Kincaid, Peterson, and Bourne) would be the main contributors to tasks 1, 2, 3, ; and that (Lefkowitz and Bourne) would be the major contributors to tasks 4-7.

cc H. Kincaid - 322
Jackie Peterson - 322
Ben Lefkowitz - 310A

Tentative NSF Schedule

~~monitor existing systems to determine what parameters are considered important?~~



TASKS

1. Develop an initial list of user's requirements to be studied
2. Develop scalar and probabilistic measures of as many of these requirements as possible
3. Develop ranking or relative weighting for as many of these requirements as possible
4. Develop a rough set of critera and a procedure that could be applied to existing systems to ~~rank~~ reach tentative conclusions about performance
5. Develop a model of a representative simple information retrieval system
6. Test the requirements, critera, and evaluation procedures of such representative systems
7. Develop plans for a research study to better describe the user's requirements and ~~procedure~~ measure criterias and evaluation procedures

TO: NSF Project File DATE: June 29, 1961

FROM: Charles Bourne

SUBJECT: Description of the User Population

To help with the planning of the survey work, I have written this memo, summarizing what might be our description of the user population, trying to: (1) describe the population as completely as possible at this time; and (2) describe the environment and type of information processes that we will be concerned with. The description has been written in such a way that it might easily be adjusted for use in the final report to explain the rationale and approach used in selecting our particular population.

There are currently about 135 members of the Engineering Division who hold one or more electrical engineering degrees (38 Ph.D, 56 M.S., 40 B.S.). A summary list of these people will be provided shortly.

I would appreciate your comments and suggestions on this note.

cc H. Kincaid - 322
J. Peterson - 322
B. Lefkowitz - 410A
R. Amara

DESCRIPTION OF THE USER POPULATION

The proposal suggests that the population segment be chosen from applied researchers in the field of electronics. For the main purposes of the project, the choice of population is not critical, since we are primarily concerned with the form of the requirements---determining which requirements can be described analytically, and which requirements are judgemental. However, the details of the requirements will be a useful by-product; for this and other reasons, it is important to accurately describe the population.

PEOPLE

As stated in an earlier memo, the sample population will be drawn entirely from the SRI staff if possible, and will include applied electronics researchers from all fields (e.g. microwave, computers)--thus yielding a cross-cut or composite sample, rather than a detailed study of a particular age group, discipline, or academic level. The study will consider only those people who have one or more degrees in Electrical Engineering. If possible, the study will consider only those individuals whose primary duty is performing research; this would necessarily exclude many management people and people with electrical engineering degrees who are not primarily engaged in performing electronics research (e.g. systems engineers). The study would also concentrate on applied researchers rather than basic researchers. It is extremely difficult to make any clear distinction between basic and applied researchers because

of the different definitions, concepts, stereotypes, images, and opinions that individuals may have about both types. However, for the purpose of this study, it may be adequate to note that the basic researchers are a minority group which may be identified to a fair degree of accuracy by some simple tests. In general, the following comparative descriptions are applicable to electronic engineers:

Basic Researcher. Generally, a basic researcher is: more inclined to write a substantial portion of his technical reports in a mathematical notation; more inclined to work in interdisciplinary projects; more interested in instrumentation equipment than other types of equipment, and is primarily interested in measuring and explaining natural phenomena.

Applied Researcher. Generally, an applied researcher: generates more formal engineering drawings; designs complex equipment; supervises the development and fabrication of prototype equipment; reads as many or more trade journals (throw-aways) than professional journals; requests components from a stock-room or vendor; deals with vendors and salesman; attempts to improve the design of existing equipment or circuits; and tries to keep current on new devices and hardware.

For an initial screening, it might be sufficient to get the lab manager's opinion as to which of his group are basic and applied.

This particular sample can not hope to speak for the entire electrical engineering population, since this sample of 50 to 100 engineers is a small fraction of the estimated total of 140,000 electronic engineers and scientists in the U.S.A. (with 110,000 in industry). There are, for example, over 88,000 electrical engineers in the Institute of Radio Engineers, the largest professional society of electrical engineers (with at least 2500 with the Bay Area). In addition to age, academic level, and other parameters, two

other factors might also be recorded for each subject to help relate this population to other groups: (1) the professional status within SRI (e.g. Research Engineer, Senior Research Engineer) and, (2) the subject's professional society status (e.g. IRE Fellow, Senior Member, Member, Associate). For the record, it should be noted that the IRE has a membership of 88,500 with a breakdown of:

1%	Fellow
11%	Sr. Member
53%	Member
15%	Associate
20%	Student
100%	

Reference: IRE Proc., June 1961, pg. 1104

ENVIRONMENT

This study is necessarily restricted to workers in a large non-profit research institute. The degree of correlation between this group and other groups such as universities, industry, and government laboratories, is not known.

TYPE OF INFORMATION REQUIREMENT

Engineers and other workers have requirements for many different types of information. Generally, the requirements might be characterized as: (1) current awareness--educational news about work that is currently in progress or being reported on; (2) specific information to help with current project work; (3) exhaustive searches which are usually performed as a separate project, or as a prelude to the major effort of a project. This study will concentrate on the ~~best~~ last two items. In particular, the study will be restricted to the requirements for formal technical literature such as ~~formal~~ journal articles

and conference proceedings. Both open source periodical literature, and the non-periodic report literature (e.g. ASTIA) will be considered. In particular, we will be interested in the type of information that would likely be incorporated into a national or regional library, or special information center for a particular subject or discipline.

Answer Rec
File

STANFORD RESEARCH INSTITUTE

To: NSF Project file

Date: August 7, 1961

From: C. Bourne

Location:

Subject: Initial List of User's Information Requirements

Answering:

One of the tasks of this project is to determine what the user's information requirements are, how they might be measured, and in what metric or units the requirements will be stated. This memo provides a first approximation to a list of requirements.

Type or form of search product (number, citation, abstract, reprint)
Quality of printing or presentation of search product
Amount of relevant material overlooked during search
Amount of irrelevant material provided with search results
Time to respond to the search request (intially and completely)
Depth or degree of indexing
    Number of discriptors per document
    Number of documents per descriptor
Type of information to be included in the file (technical papers, books, patents, reviews, etc.)
Frequency of usage of file facilities
Type of function or purpose being served by the file (current awareness, specific facts, etc.)
Capability for incorporating information into the file which is written in the important foreign languages
Provision for a current awareness or automatic dissemination capability
Capability of providing references to technical literature
Capability of providing substantive answers to technical questions
Capability of providing information concerning the source or availability of specific products or materials
Capability of providing information concerning current research and development projects
Capability to provide loan copies of technical references
Capability to provide throw-away copies of technical references
Capability to provide current copies of the indexing system and record of holdings
Capability to provide translations of material originally published in a foreign language
Value, significance, or technical excellence of the file material
Capability for handling graphic material (equations, chemical structures, etc.)
Provision for easy re-indexing, purging, and file maintenance as required
Ease of communication between system and user (codes, languages, media)
Growth capability

Receive info in briefest form possible, presented in order of importance, with necessary ancillary information, & an indication of the degree of reliability of the information.

scope / collection
timeliness
cost
depth of indexing or penetration
quality (reliability & noise)
reproducibility
physical factors (form of output, space, etc.)

Flexibility to accommodate information from new subject fields or enlarge the scope of the present coverage
Complexity of search logic that can be handled
Complete coverage of the subject fields of interest (core and fringe, X years of material)
Provision for alternate mode of operation if one or more parts of the system become inoperative
Capability for providing the following services (abstracts, interpretive summaries, annual reviews, distribution of documents, bibliographic lists, activity in collecting information, technical answering service, accession lists, index of workers, translations, patents, index to sources of information, calendar of meetings, evaluation, literature recording, summary data sheets, handbooks)
Indications of the reliability, credibility, or technical competence of each article provided
Provision for individual browsing
Minimum clerical effort demanded of user
Provision to allow the users to do their own searching
System provision for adequate management information and control
Current-awareness publications or listings for various specialty fields
System knowledge of whether or not specific information does exist? (i.e., if your search provides no references, you want to be sure that the reason for no results is the fact that no references exist)
Exhaustive search (both core material and fringe material)
Rapid feedbacks to search request (provision to re-direct the search
Nature of system response (dribbling output, botched output, quick-look)
Personal safety of operation
Storage capacity
Compatability with other information systems and communication systems
Minimum need for space, power and special installation facilities
Minimum need for training or specialization of the system personnel
Self-analysis to recover misfiled information, note missing information, obtain operating statistics on system use and performance, and generate current indexes or catalogs
Immediate and continuous system availability for searching
Capability for handling continuous or standing requests
Provision for a manual back-up system
Protection against loss of stored information
Minimum need for training or retraining of staff
Minimum delay in entering new information into the system
Minimum costs (equipment purchase or rental, maintenance, spare parts, parallel testing, conversion, initial development and programming, indexing, reproduction, storage, training, staff, etc.)
Ability to coordinate system with similar services in the same field
Ability to coordinate system with similar services in other subject fields
Automatic removal of obsolete or redundant material
Ability to handle a number of user's problems simultaneously
Ability to control semantic problems (e.g., synonyms) with minimum inconvenience to user
Ability to converse in the specialized jargon of individual specialty fields
Reliability of the search process
Reliability of the indexing

CB:jfc

Answer file
File —

TO: NSF PROJECT (3741-1) FILE AUGUST 7, 1961

FROM: CHARLES BOURNE

SUBJECT: SAMPLE MIX CONSIDERATIONS

Different engineers may have different information requirements depending upon the type of organization that they work for, their own educational background, the size of the organization (and consequently the capability of the information sources available) that they work for, the particular specialty field that they work in, and the type of work that they are engaged in (e.g. basic and theoretical; applied and experimental; management, maintenance, and service). If one of the objectives of a survey program is to obtain a composite representation of the requirements of all the engineers, then the sample must avoid any built-in bias for any of these factors. Consequently, any chosen samples should accurately reflect or approximate the total characteristics of the entire population. Completely random sampling satisfies our objectives if the sample is large enough. However, it is very difficult to obtain a truly random sample since the study--for economic and other reasons--may be restricted to one geographic area and hence one particular set of circumstances which may or may not be representative of the total population. One alternative approach is to specify in advance, how many test subjects of each particular background will be chosen--and then choose (perhaps randomly) the subjects to satisfy these specifications.

One of the primary objectives of our survey effort is to determine what requirements can be measured, and what form or metric the measurements actually take. In this regard, we don't have to be careful about biasing the sample. — not class

However, if we can obtain some useful descriptive information as a by-product of our efforts, then I think that our survey should be designed with this in mind.

One additional thought is that since previous user studies in this field have been so crude and lacking in technique, and since we have the capability of providing greatly improved work, I would very much like to see our survey work and methodology stand out on order of magnitude better than previous efforts in this field. I would hope that our work would be something that could be pointed to by NSF and others as a good example of how the work should be done.

In any case, here are some specifics regarding the makeup and characteristics of the engineering population.

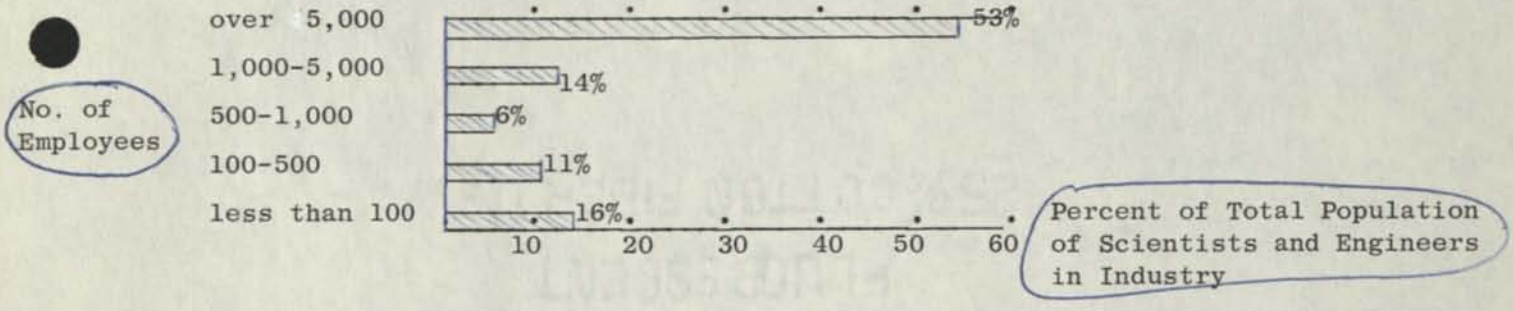
1. Distribution by Type of Organization

According to a 1958 study of the total engineering population (est. 850,000) (ref. U.S. Dept. of Labor, "Occupational Outlook Handbook," 1959 edition), engineers are distributed in the following manner:

Type of Organization	Percent of Total Engineers
Private industry	73
Federal, state, and local government agencies	15
Engineering & Architectural services (including consultants)	4
Military duty	3
Educational institutions	2
All others (non-profit org. & individual labs)	3
	100

Private industry is certainly the dominant type of organization.

2. Distribution by Size of Industrial Organizations



This information (ref. "Scientific & Technical Personnel in American Industry," NSF report 60-62 (1960)) indicates that the greatest majority of scientists and engineers in industry work for very large companies. In fact, 2/3 of all U.S. engineers and scientists work for companies with more than 1,000 employees, and over 1/2 of the U.S. engineers and scientists work for companies with more than than 5,000 employees. Our sample should be biased in favor of the larger organizations.

3. Distribution by Type of Activity

According to a 1959 study (ref. "Scientific & Technical & Personnel in American Industry," NSF report 60-62 (1960)), engineers in private industry are distributed in the following manner:

Percent of Total Enginners

Type of Function	All Types of Eng. & Scientists	Metallurgists	Engineers
Production & Operations	38.5	38.9	41.5
Research & Development	31.0	36.3	28.4
Management & Admin. of R&D	5.3	9.4	5.0
Management & Admin. of Other Activities	8.5	10.7	9.3
Exploration	1.9	0.1	0.4
All Other Activities (sales, service)	14.8	4.6	15.4
	100.0	100.0	100.0

This suggests that for the purposes of this study there may not be any significant differences between the needs of the metallurgists and the engineers, or any other specialty field of the scientific and technical community.

4. Distribution by Academic Degree

According to a 1955 study (ref. "American Science Manpower," NSF Report 59-39 (July 1959) engineering personnel have the following distributions of academic degrees.

	Bachelor	Master	Doctor
Private industry	65.9	24.5	9.6
Governmental organizations	65.5	26.3	8.2
Non-profit organizations	39.8	35.0	25.2
Educational Institutions	21.1	32.6	46.3

Electronic Industries assoc. estimated in 1961 that there were 155,000 engineers & scientists performing electronics work in all areas. 83% employed by industry, 8% in Federal govt., 5% in universities & non-profit institutions, remainder-4% includes consultants & misc.

76% of all these engineers are supported by Federal funds!

yikes!

Amann Rec.
File —

STANFORD RESEARCH INSTITUTE

To: NSF Project File 3741-1 Date: August 16, 1961

From: Charles Bourne Location:

Subject: Further Comments on User Requirements Answering:

A close examination and rework of the preliminary list of requirements stated in a previous project memo (7 August 1961) yields the following groupings of requirements:

Types of Requirements

Those which are common and independent of the systems
Search product considerations
File material considerations
System operation (in front of the counter)
System operation (in back of the counter)

The initial list of requirements has been consolidated and re-grouped under the above headings. We will probably select what we feel are the most important of each group, and use these as the basis for our questionnaires.

Common & Independent Requirements

These are the requirements that truly exist, but can be satisfied in the same way and with the same costs and results for each alternative system. For example, there is a requirement that each file be as complete as possible in the subject fields of interest to the users--this is an acquisitions problem that is the same for all systems considered. These requirements must be considered in a total evaluation of a system, but do not help with determining the differences of various systems. The

following requirements might be considered independently of their specific systems:

- Need for high value, significance, or technical excellence of the file material
- Capability for providing translations of foreign language material
- Capability for providing a duplicate of the indexing system
- Capability for providing throw-away copies of requested file items
- Need for simple acquisition procedures

Search Product

These are the requirements concerned with the actual search product given to the requestor:

- Type of form of search product (number, citation, abstract, reprint)
- Quality of printing
- Reliability of the indexing and search product (i.e. knowledge that you always get a good product)

File Material

These are the requirements concerned with the material in the file:

- Type of information to be included (technical papers, books, patents, reviews, etc.)
- Capability for accepting information written in the important foreign languages
- Capability for storing graphic material (equations, chemical structures, etc.)
- Storage capacity
- Compatability with other information systems and communication systems
- Protection against loss of stored information (e.g. information on magnetic tape).
- Minimum delay in entering new information into the system
- Automatic removal of obsolete or redundant material

System Operation (In Front of the Counter)

These are the requirements concerned with the actual over-the-counter services given to the user by the information services staff and are of most interest to the customer of the information services:

- Amount of relevant material overlooked during the search
- Amount of irrelevant material provided
- Delay to get first reference

relevant

Delay to get final reference
Total number of searches which can be handled in a given time period
Ease of communication between system and user (codes, languages, media)
Complexity of search logic that can be handled
Completeness of coverage (core and fringe material, recent and past literature)
Provision for alternate mode of operation (e.g. manual) if one or more of the system parts become inoperative
Indications of the reliability, credibility, or technical competence of each search product
Provision for user browsing
Amount of clerical effort required of user
Provision for searching directly by the user
Immediate and continuous availability for searches
Ability to control and handle language problems with minimum inconvenience to user (synonymous, jargon).

System Operation (Behind the Counter)

These are the requirements concerned with the behind-the-scenes operation of the information service, and of most interest to the organization or corporate entity that is providing the service:

File Mgmt + Control

Provision for easy re-indexing, purging, correction, and file maintenance as required
Personal safety of operation
Minimum need for space, power, and special installation or operating facilities
Minimum need for training, retraining, or specialization of system personnel
Provision of information for management and system control
Growth capability (file size, subject diversity, volume of searches, etc.)
Self-analysis to recover mis-filed information, note missing information, obtain operating statistics on system use and performance, and generate indexes or catalogs.
Minimum costs (equipment purchase or rental, maintenance, spare parts, parallel testing, conversion, initial development and programming, indexing, reproduction, storage, training, staff, etc.)
Ability to coordinate system with similar services in the same or alien subject fields.

It would seem that the type of user that we are going to interview is not qualified to answer questions or comment on these behind-the-scenes requirements. It would seem that the library directors might be better qualified since we are discussing their requirements, and not those of the over-the-counter user.

Which Ones Do We Measure?

Because of practical restrictions on time, money, and the patience of the test subject, we cannot measure each of these requirements. We must settle for measuring what we feel are the most important ones. At this point, I believe that the following requirements are important to try to measure:

Type and form of search product (number, citation, abstract, reprint); paper, film, etc.
Reliability of the indexing and search product (i.e. knowledge that you always get a good product)

File capacity (i.e. does everybody want complete access to the world's literature for every search?)
Minimum delay in entering new information into the system
Automatic removal of obsolete or redundant material

Amount of relevant material overlooked during the search
Amount of irrelevant material provided with the search result
Immediate and continuous system availability for searching
Delay to get first relevant reference
Delay to get final reference
Total number of searches which can be handled in a given time period (i.e. search productivity)
Ease of communication between system and user (codes, languages, media)
Provision for alternate mode of operation (e.g. manual) if one or more of the system parts becomes inoperative
Provision for user browsing

The following three items are important, but the over-the-counter user is not qualified to answer them:

Minimum cost
Provision for easy re-indexing, purging, correction, and file maintenance
Self-analysis to recover misfiled information, as required, note missing information, obtain system operating and performance figures, and generate indexes or catalogs

Whitby —
Amara —
File —

TO: NSF Project File 3741-1 August 18, 1961

FROM: Charles Bourne

SUBJECT: Sources for our Test Subjects

The following list describes the organizations in the immediate area that are performing electronics research, and are potential sources of interviewees for the project.

Firm	SRI Contact	No. Employees	No. Test Subjects Requested
Lockheed	Bourne	16,000	20
Ampex		4,600	12
Hewlett Packard	Whitby	3,200	15
Varian	Whitby	2,550	12
Philco		2,500	15
SRI	J. Peterson	1,800	30
Lenkurt		1,720	12
Eimac		1,700	10
Sylvania (all labs)	Whitby	1,665	15
IBM (San Jose)	Bourne	1,500	15
NASA (Moffet Field)		1,450	10
Litton		1,000	10
Rheem Semiconductor		800	5
Fairchild Semiconductor (Mt. View)		780	
Dalmo Victor		560	5
GE Microwave Lab	Bourne	425	5

Firm	SRI Contact	No. Employees	No. Test Subjects Requested
Benson-Lehner	Bourne	300	5
Sierra Electronics Corp.		230	
Dymec (Div. of H-P)		220	
Sperry Gyro		200	
Beckman & Whitely, Inc.		200	
Huggins		200	
Melabs		175	
Palo Alto Eng. Co.		175	
Link		160	
Calif. Technical Industries		140	
Shoelsley Transistor		135	
Watkins-Johnson		125	
Kaiser Air & Electronics	Whitby	110	
Vega Electronics		100	
Radiation, Inc.		100	
Kaar Engineering		100	
GE Computer Lab		100	
Levinthal	Whitby	85	
Admiral Corp.		70	
Microwave Electronics Corp.		60	
Vidya		55	
Menlo Research Labs		55	

Firm	SRI Contact	No. Employees	No. Test Subjects Requested
ITT-Farnsworth		50	
Fisher Research Lab		50	
Palomar Sci. Co.		50	
GT & E	Bourne	20	
Friden		?	
Granger Associates	Whitby	?	

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STANFORD RESEARCH INSTITUTE

To: Project File 3741-1

Date: August 28, 1961

From: Charles Bourne

Location:

Subject: Hypotheses for Testing

Answering:

HYPOTHESES THAT WILL BE PROVED OR DISPROVED BY THE SURVEY

1. Our list of requirements includes the most important ones.

2. A ranking or relative weighting can be determined for our list of requirements.

3. There are significantly different rankings of information requirements for each of the major engineering activities (i.e. project planning, equipment design, report writing, etc.).

4. There are no significant differences in the rankings of information requirements due to the individual's age, academic degree, or years of engineering experience.

5. None of the requirements on our list can be measured.

6. Not more than V% of the individuals are aware of the existence of more than 5 of the engineering indexing and abstracting services.

7. Not more than W% of the individuals have personally used (for reading or searching) more than 5 of the engineering indexing and abstracting devices.

8. Publications received from an individual's subscriptions satisfy X% of his search requirements.

9. Publications received by an individual's library satisfy Y% of his search requirements.

HYPOTHESES THAT MAY BE PROVED OR DISPROVED BY THE SURVEY

1. There are no significant differences in the rankings of information requirements due to the size (no. of total employees) or type (industry, institute, government lab, etc.) of the organization he works for.

2. There are no significant differences in the rankings of information requirements due to the individual's level of responsibility (i.e. manager, senior staff, junior staff), professional level of competence (IRE & AIEE rank) or specialty field (i.e. computers, microwave).

3. There are no significant differences in the rankings of information requirements between basic and applied researchers.

4. A basic researcher can tolerate a larger delay than the applied researcher in receiving the major portion of his search product.

5. A basic researcher requires a more complete search (larger number of sources, and over a longer publication period) than an applied researcher.

6. The use of an individual's information services (e.g. library) is proportional to the size of his information service.

7. Junior engineers are more liable to encounter problems in obtaining technical information than senior engineers are.

HYPOTHESES THAT WILL NOT BE PROVED OR DISPROVED BY THE SURVEY, BUT ARE OF INTEREST FOR FUTURE WORK

1. The individual's need for information services is proportional to the size of the information service currently available to that individual.

2. The individual's need for information services is proportional to the amount of publishing that he does.

3. For a given engineering activity (i.e. project planning, equipment design, etc.) the individual's information requirements are the same, regardless of the size or type of organization that he works for.

4. The type of information desired for inclusion in a reference retrieval system for (basic, applied, etc.) researchers is: journal and conference articles, letters to the editors, reviews, patents, books, non-periodical reports, new product announcements, and military specifications--in that order.

5. Increasing amounts of information provided to a user result in increasing productivity by that worker.

TO: Project File 3741-1 DATE: August 31, 1961

FROM: Charles Bourne

SUBJECT: ~~Outline of~~ Project ~~Progress to Date~~ Manpower Summary

cc. Amara

One third of the project time and money has been expended, and we effectively have only 2 or 2 1/2 months of productive research time ahead of us before we have to start on the reports and presentations.* This is unfortunate because there have been delays in getting personnel started on this project. Both Kincaid and Lefkowitz, for example, were away from the project for a full month during the first two months of the project, and Peterson was only available for a quarter of the time for the first month of the project. This was a handicap since their talents could have been used in the early stages, as planned, to help with the design of the survey and ~~questionnaire~~ interview guide for the determination of users' requirements. The amount of time that each of the team workers has been able to spend on the project to date (through the week ending August 26) is shown in the table below.

	July** (hours)	August (hours)
Bourne	146	126
Peterson	38	91
Whitby	--	64
Ford	24	13
Kincaid	12	8
Lefkowitz	4	--
Amara	3	4

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* (There is a contractual requirement for a final report at the conclusion of the project in December, and I think we should plan our final oral presentation in late November or early December)

** the project started on July 1.

STANFORD RESEARCH INSTITUTE

Menlo Park, California

TO: Project File 3741-1 September 12, 1961

FROM: Charles Bourne

SUBJECT: Outline of Project Progress to Date

A delay in getting personnel assigned to the project has resulted in a delay in starting the survey of user requirements. A series of pilot interviews will probably start shortly after September 11. The other tasks are approximately on schedule. However, since some of the tasks must be performed sequentially, there may be less time allocated for tasks 4, 5, 6, and 7 than we had planned. The progress to date can be described in terms of the specific tasks outlined in the proposal (pg. 9):

TASKS 1,2,3 (1) Develop an initial list of user's requirements to be studied; (2) develop scalar and probabilistic measures of as many of the requirements as possible within the level of effort of this study; (3) develop the ranking or relative weighting for as many of the requirements as possible within the level of effort of this study.

The bulk of the project work to date has been directed toward these three tasks. The activity in this area might briefly be described by the following points:

1. Review of previous literature, and questionnaires from current studies. (A great deal has been written about user requirements, and we have probably read most of it. Most of this literature has been concerned with what and where people read, how they spend their time, and where they obtain their information. Most of the user studies are concerned with improving present services and facilities--such as better abstracts, increased coverage, and more current-awareness services. In a few cases, specific requirements or suggested criteria have been described. However, no measurements, no rankings, and no attempts to measure or rank the requirements in a way that would be useful for system comparisons or evaluations have been found in the literature. The only possible exceptions are several papers which describe the complexity of search logic required by the users, as determined by a study of questions asked existing systems. However, even this measurement is very questionable because of its dependence on the type of indexing system used, and the user's familiarity with the system and subject.

The questionnaires for two currant user studies (Bell Labs, UCRL-Livermore) were studied and conversations held with their principal investigators (R.A. Kennedy, Bob Howerton, respectively).

2. Derive an initial list of requirements. (From our previous experience, from reviewing the literature, and from talking to a number of knowledgeable people about the topic, we developed an initial list of about 60 requirements and by an iterative process distilled this to a list of about 10 requirements that we feel are the most important. However, even these 10 haven't been completely accepted as a final list. Discussions on this matter have been held, for example, with Mr. Paul Howerton (CIA), Dr. Bob Howerton (UCRL-Livermore), Dr. Laurie Heilprin (CLR), Mr. Bernard Benson (Benson-Lehner Corporation), Mr. Max Mueller (Lockheed), Mrs. Claire K. Schultz (Institute for Advancement of Medical Communication), and many other people outside of SRI.

3. Determination of general methods of measuring the requirements and their rankings. (We have looked at a number of possible ways in which these measurements might be made. Because of the limited time available for this effort, it was decided to use personal interviews with research workers to obtain this information. Approximately 60 to 100 research workers will be interviewed).

4. Statement of hypotheses for testing by interviews. (A number of hypotheses have been written to serve as targets for designing the interviews and the data to be collected.)

5. Development of a suitable interview guide. (We are determined not to conduct a user study similar to those conducted previously by scores of other organizations, and have concentrated our attention, instead, on the very difficult task of trying to measure the requirements. We have been very critical of our own work, and feel that the resulting interviews and interview guide will be a significant improvement over any previous work, from the standpoint of trying to measure and rank the user requirements. We are currently working on the 4th draft of an interview guide. Fortunately, once the guide has been established, the interviews themselves should not require a great deal of time. The interview guide and methodology will be universal enough so that it could be applied to almost any population of information users.

6. Preliminary arrangements for choosing the test subjects. (A census was made of all the electronics firms in the area and their total number of employees. Data was obtained to show the character of the electronics researchers--breakdown by academic degree, type of organization, size of organization, and type of research activity--to help choose the mix of test subjects so that they are nearly representative of the composite industry, and not heavily biased in any particular direction. Quotas of test subjects from each of the selected bay area firms have been established, but with the exception of Benson-Lehner Corporation, no contacts have been made yet to secure permission for the interviews).

TASK 4

Develop a rough set of criteria and a procedure, that could be applied to existing systems in order to reach tentative conclusions about their performance.

1. Initial Screening Guidelines (rule-of-thumb criteria). Some information is being assembled on representative file sizes and accession rates for a number of file activities to show what capacities would be required of existing or proposed systems--either intellectual or hardware--for adequate performance. Data has been collected for the file volume and accession rates of U.S. College and University libraries; U.S. Public Libraries; U.S. Industrial Libraries; specific scientific subject areas; and specific indexing and abstracting services. Some thought is being given to the assembly of data to show what organizations are currently able to pay for information services, and what type of delays they currently tolerate from existing services such as ASTIA.

2. Cost Analysis as an Aid to the Evaluation. A generalizeable economic model of information retrieval system is being constructed to permit the rapid calculation of the money, labor, and equipment requirements for existing or proposed systems with any specified file volume, accession rate, search volume, and type of file organization. The model considers the following functional operations: system preparation and establishment; acquisitions; input; search; and file maintenance. The model will permit the rapid cost analysis of candidate systems with wide variations in their operational parameters. Modeling techniques are also being considered for the determination of delay times that are likely to be encountered in the candidate systems.

3. Comprehensive System Evaluation. There has been very little effort to date on the development of systematic methods for system evaluations. This work will start after the interviews and model work is well underway.

TASK 5

Develop a model of a representative, simple information retrieval system.

1. Functional models (cost, and possible time delay) are being developed. As mentioned earlier, a cost model is being developed, and a time delay model may be developed. These will be used primarily as auxiliary evaluation tools, but they could also be used as research tools to do such things as experiment with changes in parameters and the synthesis of new systems.

2. Intellectual models are being considered. Some attention is being given to modeling the intellectual processes that take place throughout many of the system operations, with the thought that a preliminary description might be developed for the more complete development of the model at some later time. It is not likely that this model will be developed to any degree during this project. During the next week, further discussions on modeling will be held with Dr. Bob Hayes (Electrada-Los Angeles) who has done an extensive amout of work on this problem. Elemental time and cost data for the model has been promised by a number of people.

TASK 6

Test the requirements, criteria, and evaluation procedures on such representative systems.

No specific systems have been chosen yet for the test of the evaluation methodology.

TASK 7

Develop plans for a research study to better describe the user's requirements, and to improve the criteria and evaluation procedures.

Some notes are being collected, but the final recommendations will be made after the completion of the major portion of our effort.

TO: Project File 3741 October 26, 1961

FROM: Charles Bourne

SUBJECT: Report of Visit with NSF on Project 3741, 24 October 1961

Roy Amara and I talked to Helen Brownson and Mr. Simon Newman today about our current NSF project. We described our work to date, indicated what progress had been made, and introduced the notion of continuing the work. Mrs. Brownson and Mr. Newman were happy with our efforts to date. They also understand that before they could apply the evaluation techniques directly to the WRU system, they would have to make specific measurements of the performance of that system and the information requirements of the metallurgists.

They would like to have an informal written report of our progress by November 15 that they could use for a forthcoming NAS-NRC meeting. They will also notify us about a convenient time for a final oral presentation.

With regard to a project renewal, Brownson suggested that any time now we could send in some informal notes on what we would like to do. However, it would probably take about 3 months to clear any proposal through the system--meaning that there cannot be NSF continuity in the present project. Brownson also raised the suggestion that our renewal would probably have to be on a grant basis rather than a regular contract.

We talked about a number of possibilities for topics of continued research, including the ones suggested by Peterson and Lefkowitz. It just happens that they are seriously contemplating doing a study of the information requirements of the metallurgy population (i.e. the potential users of the WRU system).

CB/rt

cc: Amara, Bourne, Kincaid/Peterson, Lefkowitz

STANFORD RESEARCH INSTITUTE

To: NSF Project File (3741-2) Date: August 16, 1961

From: G. Peterson Location:

Subject: Decisions on the Sample Made to Date Answering:

The following summarizes tentative decisions made concerning the sample design, evolving from the 8/11/61 meeting of Bourne, Lefkowitz, Peterson, and Whitby, and the 8/16/61 meeting of Bourne and Peterson.

1. The exact sample size cannot be determined until the length of the questionnaire (and therefore cost) is known. A minimum of 60 interviews will be conducted (permitting a three way break on any variable with a minimum of 20 in each category), and a maximum of 200. The final sample size is likely to be nearer the minimum than the maximum.

2. Interviews will be conducted in a number of peninsula firms. The purpose of spreading the survey over a number of firms is to reduce the cost (in time lost by engineers during the interview) borne by each firm. Using the minimum sample size, not more than 5-10 interviews would be conducted in any one firm. (SRI is a probable exception--the cost factor is nil since respondents may charge their time to the project.)

3. Interviews will be conducted in firms classified as small, medium, or large. With the minimum sample size, 20 interviews will be conducted in each category. If the sample size is increased, the increase will be primarily in the "large" category, since such firms account for a large proportion of all engineers.

4. The sample should be selected so that two other variables can be examined:

a. Academic degree: B.S.E.E.
M.S.E.E.
Ph.D.

b. Level of job: Sr. Engineer
Engineer
(one other?)

This means that there should be a minimum of 20 interviews in any one category.

5. There are 2 other variables which cannot be included in the sample design but which hopefully can be analyzed later:

a. Years of experience (since last degree?)
b. Type of experience (university, industry, etc.)

6. There are several other factors that will not be included in the sample design and probably cannot be analyzed later (though information concerning them will be gathered):

a. IRE status and AIEE status. It is highly unlikely we will have enough interviews in anything other than the "member" category to analyze separately.

b. Individual firm differences. There will not be enough interviews from any one firm.

c. Specialty field. It is unlikely that there will be enough interviews in any one speciality field.

NSF Project File (3741-2) August 18, 1961
cc: C. Bourne, H. Kincaid, B. Lefkowitz

G. Peterson

More and Revised Decisions on the Sample

"Decisions" will undoubtedly continue to be made; the following revise some of the statements made in my memo of August 16. The numered paragraphs below refer to paragraphs with the same number in my August 16 memo.

1. While the minimum sample size will be 60, it is hoped that at least 100 interviews can be conducted.

2. More than 10 interviews may be conducted in some firms. "What the traffic will bear" will be a guide, e.g. Lockheed may be perfectly willing to grant 20 or more interviews.

3. The "small" category of firms will not be analyzed separately unless the total number of interviews exceeds roughly 120. The large firms will account for about 2/3 of the interviews. This is approximately the proportion of EE's in the nation employed by large firms.

4. "Level of job" will be deleted from the sample design (it will be looked at later if the data permit). In its place, "type of activity" will be used--basic research, applied research, etc.

6b In view of 2 above, it may be possible to look at differences among firms.

STANFORD RESEARCH INSTITUTE

To: Charles Bourne
cc: Harry Kincaid

Date: October 3, 1961

From: Gertrude Peterson

Location:

Subject: Progress Report on 3741-2

Answering:

As you know, our portion of the study is now in the field, the interview guide has been finalized at last. The latter task was a tortuous experience, particularly for others on the project team who have not previously been closely involved with questioning and interviewing techniques. This particular project has been more difficult than most because of the nature of the subject--we are doing something that has not often, if ever, been done before. Further, the requirements of data obtained are stringent--the data must, insofar as possible, provide measures which can be used to evaluate a document retrieval system. Though we have taken more time than was planned to formulate our questions, I think we have been wise to move slowly in view of the complexity of the task.

To date, 44 interviews have been completed. Twenty-two were conducted with electronics engineers at the Institute, and 22 with electronics engineers at Lockheed. The field work is continuing, with approximately 20 interviews scheduled at IBM and 20 others at Sylvania, all in the electronics field. This portion of the field work will be concluded sometime during the week of October 16th.

In addition, a few interviews (10-20) will be conducted with metallurgists at the Institute and at one or two of the other firms mentioned above. The purpose is methodological--to try the interview guide on another discipline.

There is little I can say at this point about the content of the interviews, since no tabulations have been made. It would appear the questions using the critical incident technique are providing "meaty" information, though the data provide only an indirect metric. It is too early to determine the worth of the remaining questions. They are being answered by all respondents and are easily converted to quantitative terms. The big question is their utility as inputs to the system evaluation model.

Jackie

STANFORD RESEARCH INSTITUTE

To: Charlie Bourne Date: October 19, 1961

From: Jackie Peterson Location:

Subject: Ideas for Additional Research for NSF Answering:

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1. Naturally, I would put at the top of the list a good sample of a known population. While the purposive sample used for the present study was adequate for the intended scope, we could say a great deal more (or speak with more authority) with a good sample. (May I put in a plug here for Bill Madow? We should write him into any future proposal since he is nationally known and really tops in the intricacies of sampling.)

2. If funds are a barrier to conducting a study based on a good sample, more could be done in the future with purposive samples if the data could be gathered and analyzed in greater depth.

3. It is somewhat premature to discuss in detail our findings and what we might suggest for future work. At the same time, I feel we will have a substantial amount of interesting and useful data, and that extension, refinement, and documentation of our preliminary methods will prove worthwhile.

4. There are some additional methodological investigations that might be considered. This has been an extremely difficult study methodologically--as any pioneering effort is. I see no reason for apologizing for the first few weeks of faltering effort. I think we have cracked some nuts, but others remain.

   a. We should take another hard look at criteria from a conceptual point of view. They are not mutually independent--and the degree of interdependence is partially a function of the specific system. I'd like to see another crack taken at classifying criteria: first by type of person affected (management, system indexer or operator, user, etc.); second, try to break the criteria down conceptually into mutually exclusive bits; third, to reconstruct or synthesize the criteria in terms of interrelationships. This is a very difficult task, but I think it would help in then tackling the problem of measurement.

   b. There is another tack I would like to see considered. I am not entirely satisfied with the approach of discussing needs within the context of the user's present set-up. Theoretically, needs remain constant regardless of the existing facilities, but I suspect that the manner in

which the user expresses his needs is conditioned by the present "system" available to him. Therefore, it might be better (though perhaps even more difficult) to present the user with a series of system specifications designed to test and measure the importance of various criteria. The following is an oversimplification but is indicative of the approach.

c. Which of the following would be more suitable for you:

1. A system which would provide references within 24 hours but 50% of the references might be irrelevant.

2. A system which would provide references within one week with virtually no irrelevant material.

The difficulty of the method is to keep the number of situations presented to the user within bounds and still test the required number of criteria. If this method doesn't work, thought could be given to other methods for narrowing the gap between the user and the potential system.

The above refer generally to possible tasks as an extension of the present project. In addition, there are a number of other ideas that might be appropriate to present to NSF eventually. Some are strictly in the formulative stage. Others are not in the proposal stage but could be mentioned if you feel it is appropriate. A couple of examples of the latter are:

1. Probably one of the key issues is to learn more about the functional requirements of the users without regard for systems. This relates back to my statement earlier that theoretically needs do not vary by company but in practice they may appear to vary. The suggestion here is to determine in detail how search needs fit into the functions required of the individual and how unmet search needs (too much irrelevant material, too much time required, etc.) detract from successful (or optimal) performance. While some other user studies have approached the problem, it would appear that much remains to be learned.

2. Another suggestion is an experimental study with small groups to determine the effect of different types of systems existing today. By type I mean, for example, (a) an automated system such as a computer, (b) a standard library system such as SRI, (c) no system - where the individual is on his own, etc. The effect of each of these types and the way in which they affect the functioning and expressed needs of the user could be quite useful. For example, we could have SRI people solve a problem (say, respond to arequest for a proposal) for which information was needed and measure performance as it varied over experiemental and contact groups.

cc: Harry Kincaid

STANFORD RESEARCH INSTITUTE

To: 3741-1 File

Date: August 14, 1961

From: O. Whitby

Location:

Subject: A Proposal for an Attack on the Problem of User Requirements

Answering:

I shall assume that we are interested in discovering the user requirements in the context of the activities of the entire community of workers in the field of applied electronics. This means that we want to know not just what are the requirements of a given type of research worker or segment of the total population but we desire also a rough indication of how this worker or segment contributes to the efforts of the entire community and how this work is valued. In addition, one wants knowledge of the percentage of the total population in any one segment or group.

The segmentation of the total population into groups, the informational habits of which are or hopefully may be treated as identical, is suggested and emphasis on the value of the groups' efforts is indicated as necessary in the belief that the client will react in supplying informational services in accordance with the worth of the groups efforts and only by relatively easily identifyable groups. This means that ways should be found to relate groups, the informational needs of which are sought, to the community of research workers in applied electronics in terms of the relative size of the group and in terms of the importance of the group--salary level, worth of economic product controlled, etc.

The second idea that I want to explore is the hypothesis that pertinent to each type of activity in which research men engage is a different level of

importance to the success of the activity of information. Examples of the types of activities I have in mind are:

(1) Keeping current with technical advances in the main field of professional interest;

(2) project planning;

(3) proposal writing;

(4) report writing;

(5) equipment design

(6) conduct of laboratory experiments

It is probably widely conceded that the percentage of the total time appropriately spent during each of these activities in obtaining outside information varies considerably from one activity to another. Further, it is likely to be true that the success of each type of effort will be differently affected by the quality of support received from an information retrieval system. Both of these factors, then, should serve to modulate the importance attached to the informational efforts associated with any one of the activities.

If it is true that the nature of the job on which a research man is engaged determines both the importance and the nature of his informational activities, significance should probably be attached to the size and type of company by which such a man is employed. There is a good possibility that a research worker's position in the administrative tree will also set his informational needs. However, if the man's position in the administrative hierarchy can be adequately described by the various activities in which he is engaged, it may be possible to eliminate from the matrix coordinates considered the

normal job classifications such as: manager, project leader, senior research engineer, etc. If adequate care is given to the descriptions of the several activities in which a research man engages, it should be possible to eliminate from consideration the size of the company by which he is employed. This last point is put forth in the belief that a man's true informational needs--we are not seeking merely expressed requirements--will be governed solely by the job he is undertaking. If a difference exists between the informational needs for two seemingly identical activities in two companies of different size, the discrepancy probably exists because the activities are not identical. In this case it could undoubtedly be removed by a more accurate definition of the activity in question.

Such reasoning would lead to the need for the development of a detailed list of activities in which men doing work in applied electronics research engage. These activities should be chosen such that they involve, as little duplication as possible in informational effort from one activity to another.

In order to illustrate the type of activities I have in mind and the sort of definitions I believe may be necessary, I cite the following examples that attempt to differentiate between management activities and research work in large and small companies:

(1) professional reading: (a) own special technical field,
(b) alien but specific field,
(c) general technical.

(2) reading for information about specific activities:
(a) own industry,
(b) government contracts,
(c) conventions and symposia.

(3) technical report writing

(4) proposal writing: (a) technical,
(b) promotional.

(5) equipment design

(6) equipment testing: (a) laboratory,
(b) field,
(c) analysis of results.

(7) program planning

(8) project planning

If the informational needs associated with each of these activities can be determined, it will then be necessary to discover, for any population of men engaged in applied electronics research, the percentage of the total (yearly) man-hours spent in each area of work. Since the mix of types of research workers will vary from industry to industry and possibly with size, the basic metric--man-hours per activity--may well be as easy to apply as any when one is seeking to synthesize the informational needs for an industry, a region, a company, or whatever specific group one seeks to service.

STANFORD RESEARCH INSTITUTE

To: Charles Bourne

Date: July 17, 1961

From: Ben Lefkowitz

Location:

Subject: Questionnaire and Rank Correlation; Project 3741-3

Answering:

Here are some second and first thoughts on the project.

1. I think it wise to broaden the sample to other, nearby companies. I suspect that a user's attitude towards libraries is heavily conditioned by the library he most uses. If we interview SRI personnel alone, we will have few results that can be generalized.

2. I don't recall seeing many questions on your first draft about the user's present library facilities. Here, badly worded, is what I have in mind.

   a) On the average, how often do you use or cause to have used your company's library facilities?

   b) Do you receive by regular routing lists of abstracts, news of library acquisitions, ASTIA, compilations of technical literature (foreign and domestic) in your specialty?

   c) How many technical magazines are routed to you? How many general interest magazines? (e.g., SCIENTIFIC AMERICAN, BUSINESS WEEK).

   d) Do you often request copies of articles for general information purposes?

   e) Do you often request copies of articles on subjects you once had an interest in?

   f) Do you usually need assistance in library searches for material of direct importance to work you are doing?

   g) Aside from textbooks, do you ~~share~~ STORE in your office articles and/or abstracts of material that interest you?

   h) Does your firm charge your project for use of the library facilities? How much?

   i) By what methods do you obtain material for the library you presently use? Specify titles, key words, subject matter, authors?

So much for the questions. Recall I said that rank correlation methods can be used to answer two kinds of questions.

a) What is the degree of correspondence (concordance) among a set of observers?

b) What is the best estimate of the true ranking of the attributes based on the sample replies?

More than this, and we are involved in guesswork.

Finally, I think that my initial infatuation with pairwise comparisons was a case of over enthusiasm. It's hard to believe anybody would sit still for (let alone stay awake for) 45 comparison questions. That's asking too much of interviewer and interviewee. I think a straight ranking is sufficient for our needs.

STANFORD RESEARCH INSTITUTE

To: Charles Bourne

Date: July 26, 1961

From: Ben Lefkowitz

Location:

Subject: Project 3741-3

Answering:

Selecting A Sample of EE's

The sample should have two characteristics:

1. Represent different EE specialties insofar as the specialties have different library requirements (type and/or frequency of search).

2. Represent different libraries (type and/or size).

A listing of the IRE professional groups provides a ready means for differentiating membership interests. However, this differentiation may not be meaningful as far as library usage is concerned; e.g., members of the computer and antenna groups probably use library facilities in much the same way. A member of the technical writing group, however, probably has entirely different needs. Therefore, it might be wise to aggregate IRE professional groups by broad categories of library usage; say for example, heavy, medium, and light use—as a first guess I imagine that report writers and researchers are in the heavy category; development engineers in the medium and management and sales types in the light.

It seems reasonable to assume that a person's attitude about library facilities heavily depends on the facilities available to him. For example, I doubt you could get an intelligent opinion on key word searching from someone who has never used a library which performed this kind of search. Thus, we should select our sample to be representative of the kinds of libraries EE's generally have available. We have one strike against us because of the libraries at Stanford and Cal. Not all locations have such richly endowed facilities. But ignoring this fact, we can try to pick a sample of people who use large, medium and small libraries. What a "large" or "medium" or "small" library is cannot be answered directly. We can sidestep this issue by assuming that large firms have large libraries, etc. If this approach is acceptable, we need only get a list of Bay Area firms (including number of employees) which are likely to have EE's on the payroll.

To recapitulate, I propose we stratify the sample on two variates: type of usage and type of facility. Ideally we would like to know the percent p_i of EE's in each of the nine classes indicated below.

		Library Size					
		Large		Medium		Small	
Usage	Heavy						
	Medium						
	Light						
							N

The number of interviewees in each category would simply be p · N. We can compute the p's if we know

(1) How to categorize each IRE group by usage
(2) How to categorize local firms by library facility
(3) The group affiliation and employer of local EE's.

Requirements (1) and (2) present no great difficulty, but (3) may not be available. We can get the p's if we know the row and column sums; i.e. (1) the number of EE's in the heavy, medium and light usage categories and (2) the number of EE's in the large, medium and small firms. If we know these numbers, then we can approximate the p's individual p's in the obvious way.

STANFORD RESEARCH INSTITUTE

To: C. Bourne

Date: July 27, 1961

From: B. Lefkowitz

Location:

Subject: Project 3741-3

Answering:

You might want to make a thermofax copy of the listing. Please return it to Marianna Watson when you are finished. We are getting a more comprehensive list from the S.F. Chamber of Commerce.

This list set me thinking about our approach on this project. We take for granted that the information we want can be obtained by interviewing E.E.'s -- our concern so far has been which E.E.'s to interview. I have reservations about the average E.E.'s ability to evaluate either the service he gets or the service he wants. A well-worded questionnaire will not change the situation. Perhaps we should shift the emphasis to those more directly concerned with library functions: the librarians. I'm curious to know who is in charge of libraries at smaller companies, what resources he uses to fill requests, the service he provides, and his budget.

Essentially, I think we need a census of today's library facilities at electronics firms. I think a case can be made that these facilities fill the needs of their users. Granted the assumption, the census would give us the information we need to specify the minimum requirements of a future system. The future system would have to do at least as well as today's system.

STANFORD RESEARCH INSTITUTE

To: B. Lefkowitz, C. Bourne *Date:* 7/26

From: B. Ottinger

For further information on electronics industries in the Bay Area call the San Francisco Chamber of Commerce (EXbrook 2-4511) and ask for the Domestic Trade Department.

Project 3741-3 has been charged $3.00 for an industrial manual with pertinent statistics put out by the Chamber of Commerce.

STANFORD RESEARCH INSTITUTE

To: C. Bourne

Date: August 4, 1961

From: B. Lefkowitz

Location: E308

Subject:

Answering:

This note proves I'm still thinking about you--even when seated in front of the 704 Console.

Here's an idea for the questionnaire: The problem is how do we get a user to make a judgment about the relative importance to him of false drops vs incomplete searches. I propose a simple experiment. Suppose our user is an expert in computer logic. We show him a card containing, say, 20 titles (and associated abstracts) in some area of computer logic (e.g. error correcting codes). We tell him the list is exhaustive; it contains all information on the topic. Next we give him two lists not necessarily having equal number of titles. We tell him the two lists were produced by two information storage and retrieval systems called A and B. The A and B lists will contain many of the 20 "correct" titles and a few irrelevant ones, though not too irrelevant. (Incidentally, all lists will show expected reading times.) The false drops on the A and B lists will be the kinds of titles one would expect a storage and retrieval system to produce.

The user is asked which, if either, of the two lists he prefers. We repeat this experiment with different pairs of lists--e.g. A vs C, D vs G, etc. At the conclusion of the experiment we should be able to decide the relative importance of false drops and incomplete searches.

STANFORD RESEARCH INSTITUTE

To: Gertrude Peterson
C333

Date: October 18, 1961

From: Benjamin Lefkowitz

Location: E308

Subject: Data needed for rank correlation.

Answering:

If you have not already done so, would you please assign an identification number to each respondent. You can write this number on the questionnaire and associated IBM cards.

Would you have a research assistant prepare a worksheet as follows:

	PERFORMANCE MEASURE						
RESPONDENT	A	B	C	D	E	F	G
1							
2							
3							
4							
.							
.							
.							
N							

For each line (respondent) would you enter the results of question 17. For example, if respondent number 5 ranked the performance measure in the order: 3 7 4 1 5 2 6, then write these numbers, in that order, on the fifth line of the worksheet. Tied rankings are handled as follows:

No. of performance measures tied for ith place	Rank assigned
2	i + 1/2
3	i + 1
4	i + 3/2
5	i + 2
6	i + 5/2
7	4

BL:st

bcc: C. Bourne

STANFORD RESEARCH INSTITUTE

To: C. Bourne

Date: October 19, 1961

From: Benjamin Lefkowitz

Location: E308

Subject: Rank correlation methods applied to questionnaire Answering: results

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One of the principal tasks of the project is to develop a ranking of the performance characteristics of storage and retrieval systems. We do this by analyzing individual rankings obtained from a sample of electrical engineers.

We are concerned with two problems:

1. Measuring the agreement, or concordance, among the individual rankings, and

2. Estimating the "true" ranking of the performance characteristics.

We can answer both questions by using rank correlation methods.

The following example, based on a problem in Chapter 6 of Kendall* illustrates the procedure for computing the degree of concordance among the rankings and testing its significance.

Consider the three rankings of seven characteristics:

	a	b	c	d	e	f	g
P	1	4	2	3	5	7	6
Q	2	1	3	4	5	6	7
R	2	1	3	4	5-1/2	5-1/2	7
Total:	5	6	8	11	15-1/2	18-1/2	20

Deviations from mean

(12) -7 -6 -4 -1 3-1/2 6-1/2 8

The sum of squared deviations about the mean is S = 220.5.

Is the computed value of S significant? That is, does S = 220.5, based on the three rankings of seven objects indicate agreement among P, Q, and R?

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*Kendall, M.G. (1948), RANK CORRELATION METHODS, (2nd edition, 1955) New York: Hafner Publishing Company.

To test the significance of some sample statistic such as S, the observed value of S is compared with the entries in a frequency distribution of all values the sample statistic may take on. Each of the possible values in the frequency distribution has a certain probability of occurrence. If the probability that a random occurrence of the observed value of the statistic is sufficiently low (say .05) then we may conclude that the observed value is significant. In the present context, a significant value of S implies that the rankings P, Q and R agree.

To test the significance of S we consult a table whose entries are the probabilities of exceeding various values of S. Such a table is found in Kendall's book*. For three rankings of seven objects, the probability that the observed value exceeds 185.6 is .01. In other words, if 100 groups of three individuals were to rank seven objects randomly, the expected number of times that the calculated value of S exceeds 185.6 is one. Since the observed value of S = 220.5 exceeds the value for 1 percent, the concordance among P, Q and R cannot be explained satisfactorily by chance alone.

We now ask what is the best estimate we can make of the true ranking of the objects? Our answer is to rank according to the sums of ranks alloted to the characteristics. This gives the ranking: a b c d e f g.

BL:st

cc: Gertrude Peterson

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*See Appendix Table 6, page 186, loc cit.

Bern

11/28/61

General Gripe

To begin with let me state my objections to the procedure of measuring user requirements by sampling opinions. Primarily, I feel this approach is bad because it passes on to the user the analysis we should have done ourselves. Instead of formulating a model of document retrieval systems (DRS) which ties user requirements and system characteristics to service and cost, we ask the user to select from a limited number of choices, values of certain characteristics that, in some sense, satisfy his needs.

Opinion sampling is often the only way of proceding where information cannot be obtained analytically. For example, it would be difficult to predict voter attitudes towards some piece of legislation by analytical methods alone; e.g., regression analysis. However, where an analytical approach is possible we should not rely on opinions. We would not poll stock clerks when designing an inventory control system. Rather we would construct a model of the system from which we could derive optimal procedures.

One trouble with opinion sampling is that it raises more questions than it answers. Why, for example, did just about everybody think the minimum time characteristic the most important? What percentage of false drops would the respondents tolerate to get faster search times? We cannot ask the users this question because it is so hypothetical, it probably cannot be answered to anyone's satisfaction. Yet this is a most important question from the standpoint of the DRS designer and builder.

We now have developed a framework for describing a DRS in terms of cost and service. Although there are many formidable problems involved in applying this model, it is I feel, structurally sound. It's input are measurements of performance and costs and not the opinions of potential users.

Because of the above objections, I think we should soft-pedal the idea that the client should evaluate a DRS on the basis of the responses to our questionnaire. The whole procedure rests on shaky assumptions and I'm afraid this will be apparent to the client and competing firms.

11/27/61

It is desired to assign figures of merit to each DRS by how well it satisfies two requirements: (1) minimize the time to get the major group of relevant references and (2) minimize the amount of irrelevant material produced. Because both indexes are ~~deneed~~ derived in a similar way, only the derivation for the minimum time index is presented.

Minimum time requirement

The average service time per search will be used to measure how well a DRS satisfies the first requirement. This statistic is computed by compounding the distributions of DRS service time and user waiting time.

User Waiting Time

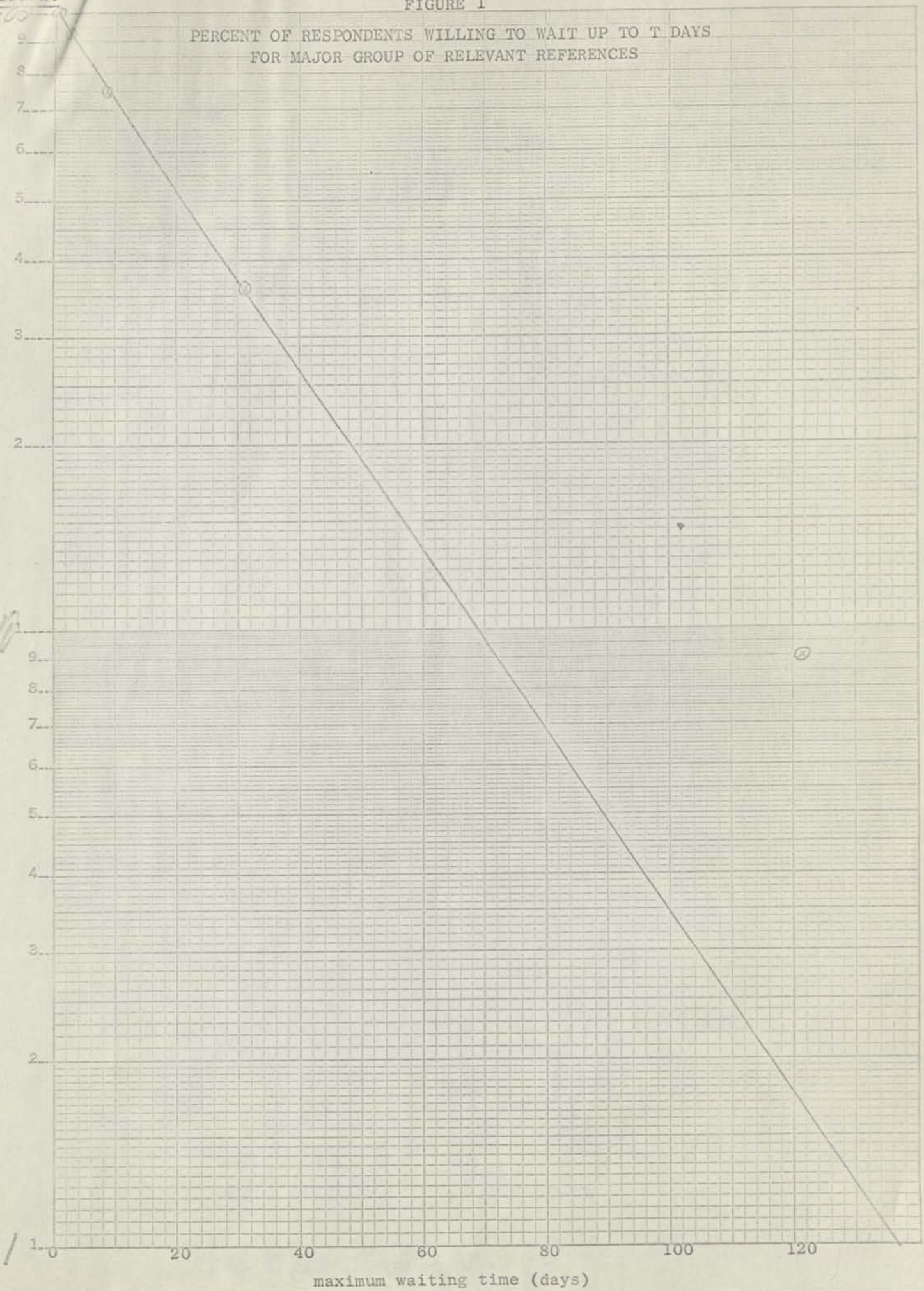
Let n_t be the number of sample members who will wait up to time t for search results and let N be the sample size. Table 1 shows the proportion n_t/N, of sample members willing to wait until time t for the relevant references. The data in Table 1 was derived from 44 responses to question 11 in the questionnaire. Figure 1 is a graph of the data shown in Table 1.

Table 1

Max time to get relevant references (days)	Interval mid-point (day)	n_t/N
≤ 1	1/2	100
2- 3	2-1/2	93
4- 13	8-1/2	75
14- 49	31-1/2	36
61- 182	121-1/2	9
~~more than~~ > 182	--	0

FIGURE 1

PERCENT OF RESPONDENTS WILLING TO WAIT UP TO T DAYS
FOR MAJOR GROUP OF RELEVANT REFERENCES



(Note to Bourne: Question 11 is badly formulated. First, the wording of the last category allows for the possibility that four respondents--9 percent of the sample--would be satisfied if they never received search results. The entire question should have asked the respondent to specify his maximum tolerable waiting time. Second, the time interval in the next-to-last category (2-6 months) is so long that it is hard to estimate how long the 12 respondents in this category really would be willing to wait. For all categories it is assumed that the respondents were willing to wait until the interval mid-point. Thus, respondents who said they would be willing to wait 2-6 months, were treated as though they would be willing to wait 4-~~12~~ months.)

Figure 1 suggests that the distribution of n_t/N is exponential. As applied to this problem, the exponential assumption means that, in the discrete case,

$$n_t - n_{t-1} = k(N-n_{t-1})$$

where k, the "decay constant," is the reciprocal of mean user waiting time. The difference equation says that the number of respondents in the interval from time t-1 to t is proportional to the number of respondents not satisfied before time t-1. The continuous analog of this difference equation is

$$dn_t = k(N-n_t)dt$$

or

$$\frac{1}{(N-n_t)} \frac{dn_t}{dt} = k$$

which integrated gives

$$c+\log(N-n_t) = kt$$

where c is the constant of integration. At t=0, $n_t = 0$, so that $c = -\log N$. Therefore

$$\log(N-n_t) = -kt + \log N$$

Solving for n_t

$$n_t = N(1-e^{-kt})$$

Finally

$$n_t/N = 1-e^{-kt}$$

The quotient n_t/N is the proportion of respondents who want search results by at most time t. The value of k could be estimated by the least squares fitting technique. However, the result would be heavily influenced by one outlying point; the 2-6 months interval point. If this interval had been 2-3 months and the change had not effected the responses, then the exponential assumption gives a very good fit. When the outlying point is ignored, k, the slope of the line in Figure 1, has the value k = .037.

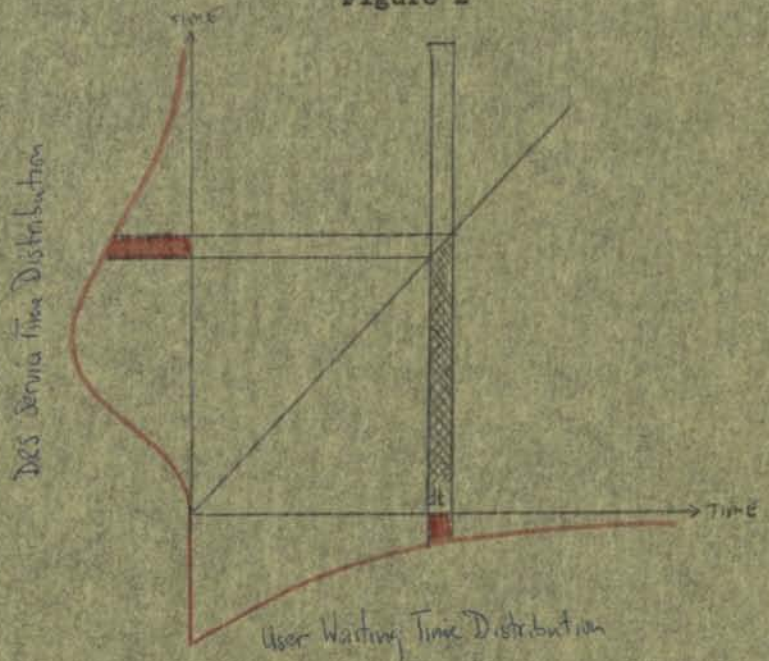
DRS service time

No empirical data is available on DRS service time, although such data could be developed through a program of experimentation on prototype systems. For the following analysis, the DRS service time distribution is denoted by g(t).

Average service time per search

Figure 2 will help explain how the average service time per search is computed.

Figure 2



The discussion represents user waiting time, and the distribution below the axis shows the proportion of users willing to wait up to the corresponding time on the axis. Thus, the dark area below time dt is the proportion of users willing to wait till time dt.

The ordinate is also measured in units of time, in this case the amount of time required by a DRS to satisfy a search request. The disbribution appended to the ordinate is the probability a search will be satisfied by the given time. The dark area to the left of time interval dt is the probability a search is satisfied in that interval.

Consider a single user, one willing to wait up to time dt for search results. This user will generate many searches, some that can be serviced quickly, others which take considerable time to satisfy. It is assumed that the search times required to satisfy his requests are distributed uniformly over time. The column with base dt represents the searches generated by the particular user. Of these searches, only those satisfied by time dt--that is, the cross-hatched area of the column--are successful. Therefore, total user satisfaction is obtained by taking the double integral of the product of the user waiting time and DRS service time distributions. The limits on the waiting time distribution run from zero to infinity while the limits on the DRS service time distribution run from zero to t.

Let $\frac{n(t_1)}{N}$ = proportion of users willing to wait until time t_1

$g(t_2)$ = probability a search is completed in time interval t_2

Then the average time per search, signified $\bar{T}$, is,

$$\bar{T} = \int_0^{\infty} \frac{n(t_1)}{N} \int_0^{t_1} g(t_2)\, dt_2\, dt_1$$

But by a previous result

$$\frac{n_t}{N} = 1 - e^{-kt}$$

Therefore

$$\bar{T} = \int_0^{\infty} \int_0^{t_1} k e^{-kt} g(t_2)\, dt_2\, dt_1,$$

or

$$\bar{T} = \int_0^{\infty} e^{-kt_2} g(t_2)\, dt_2$$

This is as far as the analysis can be carried without knowledge of the form of g(t).

If the DRS service time distribution, g(t) is exponential, then

$$\bar{T} = \frac{\frac{1}{K}}{\frac{1}{a} + \frac{1}{k}},$$

where 1/a is the mean DRS service time, ~~Recall that~~ and 1/k is the mean user waiting time.

Note that as 1/a becomes very large relative to 1/k the quotient approaches zero. Conversely when 1/a becomes small relative to 1/k the quotient approaches 1, Therefore,

$$0 < \bar{T} < 1$$

The critical assumption underlying the above analysis is the independence of the user waiting time and DRS service time distribution. This assumption may not be true. It is quite possible that the users who are willing to wait a long time for search results are the ones whose search requests normally take a long time to satisfy. If the independence assumption is false, then $\bar{T}$ will be a conservative figure of merit.

Minimum irrelevant material requirement

As stated earlier, the derivation of the minimum irrelevant material index--called the average percentage of false drops per search, and signified $\bar{D}$--is not presented. The steps followed in deriving the average service time per search index $\bar{T}$, are repeated in deriving the expression for $\bar{D}$. The appropriate distribution in this case is the percent of users willing to accept up to d false drops, and the probability a DRS will produce d false drops.

The result is

$$\bar{D} = \frac{\frac{1}{b}}{\frac{1}{c}+\frac{1}{b}} ,$$

when $\frac{1}{b}$ is the mean number of false drops acceptable to the users and $\frac{1}{c}$ is the mean number of false drops produced by the DRS. Again $0 < \bar{D} < 1$.

It should be emphasized that the independence assumption underlying the analysis has not been verified. That is, it may be that users who will tolerate a high proportion of false drops submit search requests likely to produce a large number of false drops.

~~Pre-test~~ FINAL FORM

Interviewer _____

Stanford Research Institute
3741-2

We are conducting a study, under NSF sponsorship, to develop methods for evaluating the performance of document retrieval systems. To do this, we have to know the needs of users of documents. So we are talking to some researchers in electronics in various companies about their own document needs.

Let me give you definitions for two terms I'll be using throughout this interview. (HAND RESPONDENT CARD A AND LET HIM READ WITH YOU.)

> First, I am concerned with document retrieval - that is, the retrieval of entire documents, abstracts, or citations of documents. I am not concerned with information retrieval - that is, general information in response to a request, nor with data retrieval - that is, the retrieval of specific facts.
>
> Second, is the term search. This is when you, or someone else at your request, looks for references and/or documents on a given subject. A search can be extensive and made through one or more libraries, or it can be very brief - such as looking through sources you keep in your own office. Not included are requests for specific documents that you know deal with the subject. For example, you are not searching when you ask the library to send you a specific issue of the IRE Proceedings.
>
> (TAKE BACK CARD A)

1. Keeping this definition in mind, have you, or anyone requested by you, conducted any searches in the last year?

_____ Yes _____ No (IF NO, SKIP TO Q. 20)

(IF YES, ASK:)

2. Roughly, how many? _____

3a. Here is a list of some activities EE's work in (HAND RESPONDENT CARD B). In what one activity do you spend the most working time?

3b. Which activities account for the majority of your searches? (IF RESPONDENT GIVES MORE THAN THREE, ASK FOR THREE THAT ACCOUNT FOR THE MOST SEARCHES.)

3c. Now I'd like to ask you about the most recent search you did or had someone else do while engaged in one of the activities you named. Which of the activities you named required this search?

	Q. 3a	Q. 3b	Q. 3c
	One Activity Most Working Time	Three Activities Majority of Searches	One Activity Most Recent Search
a. General project planning			
b. Theoretical design of experiments			
c. Design of equipment, systems, and procedures			
d. Conduct of lab experiments or field tests			
e. Correlation of experimental results with theory, or vice versa			
f. Review & evaluation of a specific project or product (a critique)			
g. Technical report writing			
h. Technical proposal writing			
i. Preparation of lectures or technical papers			
j. Keeping current with technical advances			
k. Search for novel technical ideas on which to base new projects or new research			
l. Serving as a consultant			

(TAKE BACK CARD B)

4. Do you recall some of the details of this search?

_____ Yes _____ No (IF NO, SKIP TO Q.20)

5a. Do you recall anything happening during the search that made it an easier or better search, or that made the search difficult? For example, what was the most difficult or irritating thing that happened? (PROBE)

_____

_____

_____

5b. What was the easiest or most gratifying thing that happened? (PROBE)

_____

_____

_____

5c. If a young engineer who had just joined the staff were starting this same search today, what advice would you give him to make the search easier? (PROBE)

_____

_____

_____

5d. What would you warn him about? (PROBE)

_____

_____

_____

6. Who conducted the search - you, a co-worker, a librarian, or someone else?

_____ Self
_____ Co-worker
_____ Librarian
_____ Other _____

7. Do you recall the exact nature of your request--that is, did you just generally describe the subject, were certain terms used, or what?

_____

_____

8. Through what library or other offices was the search conducted?

_____ Company library
_____ ASTIA
_____ University or college
_____ Other _____

9. Which of these statements most nearly describes how urgently you needed the search results when you requested the search? Ignore the importance of the results when you received them - we'll get to that next. (HAND RESPONDENT CARD C)

_____ Very urgent; other work held up. E.g., a search for information on the characteristics of a substance to be used in a current experiment.

_____ Important; needed to help determine course of future work or to help fill in gaps in your knowledge. E.g., a search for information on the performance of one of a class of possible circuits to be used in a piece of equipment.

_____ Not very important; completeness of search results had little priority. E.g., a bibliography to be used as supplementary information.

(TAKE BACK CARD C)

10. Sometimes a search turns up significant information and sometimes it adds little to the searcher's knowledge. Which of these statements most nearly describes how important the results were? (HAND RESPONDENT CARD D)

_____ Very important. E.g., changed the course of a project, provided key information needed to obtain a contract.

_____ Not very important. E.g., results were used as supplementary or back-up material.

_____ Unimportant. E.g., results had little or no effect on course of work.

(TAKE BACK CARD D)

11a. Approximately how long was it from the time you made your request until you had received the major group of relevant references?

11b. Was this adequate or did you really need the material sooner? (IF NEEDED SOONER, ASK HOW SOON)

11c. What was the maximum amount of time you could have waited for the major group of relevant references?

	Q. 11a	Q. 11b	Q. 11c
	Actual	Adequate	Maximum
1 day or less			
2 - 3 days			
4 - 13 days			
2 - 7 weeks			
2 - 6 months			
more than 6 months			

12a. How old were the most recent references turned up by the search? In other words, how recent was the material covered by the search?

12b. Was this adequate or did you really need more recent material? (IF NEEDED MORE RECENT MATERIAL, ASK HOW RECENT.)

12c. Could you have gotten by with references that were all _____ (6 months or older, 1 year or older, etc.)? (START WITH CATEGORY AFTER "ADEQUATE" AND CONTINUE UNTIL RESPONDENT SAYS "NO".)

	Q. 12a	Q. 12b	Q. 12c	
	Actual	Adequate	Gotten by?	
			Yes	No
Under 3 months				
3 - 5 months				
6 - 11 months				
1 - 2 years				
Over 2 years				
Over 10 years				

13a. In what forms did the recovered references come to you? (READ LIST)

13b. Which of these do you generally prefer for this type of search?

13c. Which of the others are not preferred but generally adequate?

13d. Are there any that you consider inadequate for this type of search?

	Q. 13a	Q. 13b	Q. 13c	Q. 13d
	Actual	Preferred	Adequate	Inadequate
Complete document				
Abstract				
Citation				
Document number				

14a. Some irrelevant material is usually turned up in a search. What proportion of the total time you spent on this search would you guess was spent in culling out irrelevant or duplicate material?

14b. Was that about right or should you have had to spend less of your time culling our irrelevant or duplicate material? (IF LESS, ASK WHAT PROPORTION)

14c. Of the time you spent on the search, what is the maximum proportion of your time you would have been willing to spend culling out irrelevant material?

	Q. 14a	Q. 14b	Q. 14c
	Actual	About right	Maximum
Less than 1/4			
1/4 but less than 1/2			
1/2 but less than 3/4			
3/4 or more			

15. (HAND RESPONDENT CARD E AND READ ALONG WITH HIM) I am going to show you 7 cards, each of which contains a statement about a performance measure by which document retrieval systems can be judged. It is important to realize that these measures are to a degree in conflict with one another. For example, if you want your requests satisfied as quickly as possible, you normally must expect that some relevant material will be overlooked. Similarly, if you want the system to produce all or nearly all the relevant documents, then you must expect a large number of irrelevant documents in the results. (HAND RESPONDENT GROUP OF CARDS)

Please put these items in the order in which you would least want to compromise on the type of search we've been discussing. Put those you feel strongly you wouldn't want to compromise on your left, those you wouldn't mind compromising on your right, and the others in the middle. Now, put those in each group in order. If you feel two items are equal in importance, put them together.

Order

_____ a. Minimum time to get the major group of relevant references to you.
_____ b. Minimum of irrelevant material produced by the search
_____ c. Minimum of relevant material overlooked by the search
_____ d. References come to you in form you prefer (complete document, abstract, citation, or document number)
_____ e. Assurance that documents on a given subject do not exist
_____ f. Minimum of effort on your part to communicate your request for a search
_____ g. Certainty that specified sources over certain period of time were searched (certain that 100 percent of the sources were searched, certain that 90% were searched but 10% may not have been searched, etc.)

(AFTER RECORDING, TAKE BACK CARD E AND GROUP OF CARDS.)

16a. On the type of search we've been discussing, how long from the time you make your request can you generally wait for a search which covers 50% of the potential sources?

16b. How long for a search covering 80%?

16c. How long for a search covering all or almost all potential sources?

Q. 16a 50% _____
Q. 16b 80% _____
Q. 16c Almost all _____

17a. Again on the type of search we've been discussing, how many of your own working days, weeks, or months would you be willing to spend on the search if you could be sure 50% of the relevant sources were located?

17b. How much if 80% of the relevant sources were located?

17c. And if almost all were located?

Q. 17a 50% _____
Q. 17b 80% _____
Q. 17c Almost all _____

18a. Let's assume for a moment that you initiated a search of the type we've been discussing. Let's say that you personally have spent X amount of time on the search and that the search covered sources up through 2 years ago but nothing more recent. Proportionately how much more working time would you personally be willing to spend to see that sources up through 1 year ago were covered? (OBTAIN ANSWERS IN MULTIPLES OF "X" - "Half again as much time," Twice as much," etc.)

18b. How much to see that sources up through 6 months age were located?

18c. And sources up through 1 month ago?

Q. 18a Up through 1 year ago _____
Q. 18b Up through 6 months ago _____
Q. 18c Up through 1 month ago _____

19a. And now a general question about your needs for coverage - that is, the number of sources and period of time covered - for <u>all the kinds of searches</u> you have done in the past few years. <u>How often could you have used these types of searches</u>, ignoring the fact that you may have been unable to do these searches with current tools? (HAND RESPONDENT CARD F)

For the last 5 years of publication:

	Often	Once in Awhile	Never
The contents of 15 or less journals of special interest to you	_____	_____	_____
The contents of all the journals covered by the major indexing & abstracting services in your field	_____	_____	_____
The contents of all the U.S. scientific & technical journals	_____	_____	_____
The contents of all English speaking scientific and technical journals	_____	_____	_____
The contents of all the world's scientific & technical journals	_____	_____	_____

(TAKE BACK CARD F)

19b. Would your answers differ in you weren't limited to searching the last 5 years of publication? (IF YES, ASK HOW ANSWERS WOULD DIFFER)

_____

_____

_____

And now a few background questions.

20. Name _____

21. Company _____

22. What is your job title? _____

23. Would you classify yourself as a research manager, a senior engineer, an engineer, or a junior engineer?

_____ Research manager
_____ Senior engineer
_____ Engineer
_____ Junior engineer

24. In a general technical sense, what do you consider to be your specialy field? For example, computer design, microwave circuit and techniques, etc.

_____

25. What is the highest academic degree you hold and what year was it conferred?

	Degree	Year conferred
_____	BSEE	_____
_____	MSEE	_____
_____	Engineer	_____
_____	PhD, ScD	_____
_____	Other _____	_____

26. Are you a member of IRE or of AIEE? If so, what type of membership do you hold?

IRE	AIEE
_____ Not a member	_____ Not a member
_____ Fellow	_____ Fellow
_____ Sr. member	_____ Member
_____ Member	_____ Associate
_____ Associate	

27. How many years of working engineering experience have you had in these types of organizations? (READ LIST)

Years

_____ University
_____ Research Institute
_____ Industry
_____ Government Labs or Offices
_____ Independent Consulting

_____ TOTAL

28. Have you authored any publications or given any technical papers in the last three years? If so, how many technical articles or papers? Any books? Anything else?

_____ None
_____ Technical articles or technical papers
_____ Books
_____ Other _____

29. Into which of the following age groups do you fall? (READ LIST)

_____ Under 25
_____ 25 to 29
_____ 30 to 34
_____ 35 to 39
_____ 40 to 44
_____ 45 and over

Date _____

Length of Interview _____ minutes

Interviewer_____

Stanford Research Institute
37ɥ1-2 2nd Draft

We are conducting a study, under NSF sponsorship, to develop methods for evaluating the performance of document retrieval systems. A critical part of any evaluation procedure is the determination of whether or not the needs of users are met. We are therefore trying to get some measures of document needs among active researchers in the electronics field to use in developing evaluation methods for document retrieval systems.

There are two definitions I'd like to give you first, so that we will both be talking about the same thing throughout the interview.

document " data retrieval info "

First, we are concerned with document retrieval - that is, entire documents, abstracts, or citations of documents. We are not concerned with information retrieval - that is, the retrieval of specific facts. (data)

Second, I'll use the term search quite often. This means occasions when you or someone assigned by you tried to locate references on a given subject or subjects. A search can be large and extensive or very brief. Included are requests made through a library for documents on a particular subject. Not included are requests for specific documents known by you to deal with the subject.

We need to know what types of activities you engage in and what proportion of your working time you spend in each. Here is a list (HAND RESPONDENT CARD A) of some activities EE's engage in.

1. Which of these activities have you engaged in during the past year?

   Are there any other activities you have engaged in during the past year?

(FOR EACH ACTIVITY ENGAGED IN:)

2. What percent of your working time was spent in _____? (BE SURE ANSWERS TOTAL 100%)

3. Did you conduct a search during the last year while engaged in _____?

(FOR EACH SEARCH, ASK:) (NOTE: IF MORE THAN ONE SEARCH IN ONE ACTIVITY, ASK ABOUT MOST RECENT ONE)

4. Was the search critical to the success or failure of the task, or was it supplementary to other more important parts of the task? Leverage ↓

	Q. 1		Q. 2	Q. 3		Q. 4	
	Engaged in		%	Search Conducted		Search Was:	
	Yes	No	of Time	Yes	No	Critical	Supplement
a. Planning of programs and projects							
b. Design of equipment, systems, and procedures							
c. Conduct of lab experiments or field tests							
d. Review and evaluation of a specific project or product							
e. Preparation of lectures or technical papers							
f. Technical report writing							
g. Proposal writing							
h. Keeping current with technical advances							

(Note: Space for "Other" to be added)

What does this have to do with info needs

Looks like a use survey.

(HAND RESPONDENT CARD B)

5. Would you go through this list and tell me which publications you personally subscribe to, and which additional publications you scan regularly?

	Sub-scribe	Scan		Sub-scribe	Scan		Sub-scribe	Scan		Sub-scribe	Scan
1			31			61			91		
2			32			62			92		
3			33			63			93		
4			34			64			94		
5			35			65			95		
6			36			66			96		
7			37			67			97		
8			38			68			98		
9			39			69			99		
10			40			70			100		
11			41			71			101		
12			42			72			102		
13			43			73			103		
14			44			74			104		
15			45			75			105		
16			46			76			106		
17			47			77			107		
18			48			78			108		
19			49			79			109		
20			50			80			110		
21			51			81			111		
22			52			82			112		
23			53			83					
24			54			84					
25			55			85					
26			56			86					
27			57			87					
28			58			88					
29			59			89					
30			60			90					

6. Are there any other technical publications that you personally subscribe to or scan regularly?

Subscribe	Scan

7. On most searches you require, what fraction of the search is satisfied by the publications you personally subscribe to?

Purpose?

_____ Less than 1/4
_____ 1/4 but less than 1/2
_____ 1/2 but less than 3/4
_____ 3/4 or more

(HAND RESPONDENT CARD C)

8. Which of these indexing or abstracting services are you familiar with? Are there any others you can think of that are not on the list?

Purpose.

9. Which have you personally had occasion to use in the last year? Any others you can think of?

Card C ↓

Q. 8 Familiar With	Q. 9 Have Used	
		a. Aero/Space Reviews
		b. AGM Computing Reviews
		c. Applied Mechanics Reviews
		d. Applied Sciences and Rechnology Index (formerly Industrial Arts Index)
		e. ASTIA Technical Abstracts Bulletin
		f. Battelle Technical Review
		g. Dissertation Abstracts
		h. Engineering Index
		i. Instrumentation Abstracts
		j. IRE-PGE Abstracts (same as Computer Abstracts)
		k. IRE Proceedings Abstracts (same as Electronic Technology)
		l. Lectrodex (formerly Radiofile)
		m. Masters Theses in Pure and Applied Sciences
		n. Mathematical Reviews
		o. Nuclear Science Abstracts
		p. Science Abstracts: A. Physics Abstracts
		q. Science Abstracts: B. Electrical Engineering Abstracts
		r. Solid State Abstracts (formerly Semiconductor Abstracts
		s. U.S. Government Research Reports

Are we looking at needs in terms of the file material also?

(THE FOLLOWING QUESTIONS ARE TO BE ASKED CONCERNING EACH CRITICAL SEARCH. IF MORE THAN THREE CRITICAL SEARCHES WERE CONDUCTED, FOLLOW INSTRUCTIONS FOR SELECTING THREE THREE.)

10. Do you recall anything happening during the search that made it an easier or better search -- or that made the search difficult? Please describe. (PROBE IN DEPTH)

Describes present system.

11. Who conducted the search - you, a co-worker, a librarian, or someone else?

__Self	__Self	__Self
__Co-worker	__Co-worker	__Co-worker
__Librarian	__Librarian	__Librarian
__Other_____	__Other_____	__Other_____

12. What period of time was covered by the literature?

__6 months	__6 months	__6 months
__1 year	__1 year	__1 year
__2 years	__2 years	__2 years
__3 years	__3 years	__3 years
__4-5 years	__4-5 years	__4-5 years
__6-10 years	__6-10 years	__6-10 years
__Over 10 _____	__Over 10 _____	__Over 10 _____

(HAND RESPONDENT CARD C)

13. Were any of these indexing or abstracting services used in the search? If so, which ones?

None	j.	None	j.	None	j.
a.	k.	a.	k.	a.	k.
b.	l.	b.	l.	b.	l.
c.	m.	c.	m.	c.	m.
d.	n.	d.	n.	d.	n.
e.	o.	e.	o.	e.	o.
f.	p.	f.	p.	f.	p.
g.	q.	g.	q.	g.	q.
h.	r.	h.	r.	h.	r.
i.	s.	i.	s.	i.	s.

14. If searching was done in specific journals, what were the names of the journals. This list may help. (HAND RESPONDENT CARD B.) (RECORD NUMBERS OF JOURNALS ON LIST, AND NAMES OF THOSE NOT ON THE LIST.)

Numbers:		Numbers:		Numbers:	
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Other Journals	Other Journals	Other Journals
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

15. Through what library or other offices was the search conducted?

____ Company Library	____ Company Library	____ Company Library
____ ASTIA	____ ASTIA	____ ASTIA
____ University or college	____ University or college	____ University or college
____ Other _____	____ Other _____	____ Other _____

16. Can you tell me the approximate total number of references the search turned up. I mean the total number, regardless of whether they were relevant or redundant and regardless of whether you asked for the specific document or used it.

_____	_____	_____

Now I'm going to ask a couple of questions about this total number of references. If you prefer to answer in percentages, please do so.

17. In what form did the list of references originally reach you? As I read the list, tell me the number of references in each category.

____ Document number	____ Document number	____ Document number
____ Citation	____ Citation	____ Citation
____ Abstract	____ Abstract	____ Abstract
____ Complete document	____ Complete document	____ Complete document

ok But this is present performance.

18. How would you apportion the total number of references turned up in the search among the following: (READ LIST)

____ Relevant	____ Relevant	____ Relevant
____ Relevant, but duplication of other references in same list	____ Relevant, but duplication of other references in same list	____ Relevant, but duplication of other references in same list
____ Irrelevant	____ Irrelevant	____ Irrelevant

19. How long was it from the time you made the search request until you received your first relevant reference?

____ Within 1 day	____ Within 1 day	____ Within 1 day
____ Within 3 days	____ Within 3 days	____ Within 3 days
____ Within 1 week	____ Within 1 week	____ Within 1 week
____ Within 2 weeks	____ Within 2 weeks	____ Within 2 weeks
____ Within 1 month	____ Within 1 month	____ Within 1 month
____ Within 6 weeks	____ Within 6 weeks	____ Within 6 weeks
____ Within 2 months	____ Within 2 months	____ Within 2 months
____ More than 2 months _____	____ More than 2 months _____	____ More than 2 months _____

Poor Performance

20. How long was it from the time you made the search request until you received your final relevant reference?

____ Within 1 day	____ Within 1 day	____ Within 1 day
____ Within 3 days	____ Within 3 days	____ Within 3 days
____ Within 1 week	____ Within 1 week	____ Within 1 week
____ Within 2 weeks	____ Within 2 weeks	____ Within 2 weeks
____ Within 1 month	____ Within 1 month	____ Within 1 month
____ Within 6 weeks	____ Within 6 weeks	____ Within 6 weeks
____ Within 2 months	____ Within 2 months	____ Within 2 months
____ Within 6 months	____ Within 6 months	____ Within 6 months
____ More than 6 months _____	____ More than 6 months _____	____ More than 6 months _____

21. Do you recall the exact nature of your request--that is, did you just generally describe the subject, were certain terms used, or what?

_____ _____ _____

_____ _____ _____

_____ _____ _____

Now I'd like to ask some questions about what you want in document retrieval systems. Please keep your answers realistic. For example, you could say you wanted all relevant documents within an hour. But we need to know when you <u>really need</u> them.

In the following questions I want you to tell me what is <u>adequate</u> for you--that is, the requirements within which you can work effectively. I also want to know if there is a level which is inadequate--that is, a level which you feel is simply not good enough.

(NOTE: EXPLAIN HERE THE REFERENCE. THE FIRST SET OF QUESTIONS WILL BE ABOUT ALL SEARCHES IN GENERAL. THE OTHERS WILL BE ABOUT SPECIFIC TYPES OF SEARCHES.)

22. I'd like your opinion of the amount of time required to get the major group of relevant references to the requestor. What is generally adequate? Is there a time limit above which is generally inadequate?

urgency.

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	1 day	____	____	1 day	____	____	1 day
____	____	3 days	____	____	3 days	____	____	3 days
____	____	1 week	____	____	1 week	____	____	1 week
____	____	2 weeks	____	____	2 weeks	____	____	2 weeks
____	____	1 month	____	____	1 month	____	____	1 month
____	____	6 weeks	____	____	6 weeks	____	____	6 weeks
____	____	2 months	____	____	2 months	____	____	2 months
____	____	6 months	____	____	6 months	____	____	6 months
____	____	More than 6 months	____	____	More than 6 months	____	____	More than 6 months

23. And what about the amount of time required to enter new information into the file system. What is generally adequate? What is generally inadequate?

? ?

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	1 day	____	____	1 day	____	____	1 day
____	____	3 days	____	____	3 days	____	____	3 days
____	____	1 week	____	____	1 week	____	____	1 week
____	____	2 weeks	____	____	2 weeks	____	____	2 weeks
____	____	1 month	____	____	1 month	____	____	1 month
____	____	6 weeks	____	____	6 weeks	____	____	6 weeks
____	____	2 months	____	____	2 months	____	____	2 months
____	____	6 months	____	____	6 months	____	____	6 months
____	____	More than 6 months	____	____	More than 6 months	____	____	More than 6 months

How is kind of concern?

Aren't we going to tie this to research activity?

24. Some irrelevant material is usually turned up in a search. What proportion of irrelevant material would you expect in what you might call an adequate search? Is there a proportion above which is inadequate?

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	10%	____	____	10%	____	____	10%
____	____	11-20%	____	____	11-20%	____	____	11-20%
____	____	21-30%	____	____	21-30%	____	____	21-30%
____	____	31-40%	____	____	31-40%	____	____	31-40%
____	____	41-50%	____	____	41-50%	____	____	41-50%
____	____	51-60%	____	____	51-60%	____	____	51-60%
____	____	61-70%	____	____	61-70%	____	____	61-70%
____	____	71-80%	____	____	71-80%	____	____	71-80%
____	____	81-90%	____	____	81-90%	____	____	81-90%
____	____	91-100%	____	____	91-100%	____	____	91-100%

Time to weed out irrelevant material would be a better criterion as time spent on accumulating irrelevant material

25. Concerning intellectual form of the search product, which of the following usually are adequate for you? Are any usually inadequate?

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	Complete document	____	____	Complete document	____	____	Complete document
____	____	Abstract	____	____	Abstract	____	____	Abstract
____	____	Citation	____	____	Citation	____	____	Citation
____	____	Document number	____	____	Document number	____	____	Document number

format

Difference?

26. Concerning physical form of the search product, which of the following usually are adequate for you? Are any usually inadequate?

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	Reprints	____	____	Reprints	____	____	Reprints
____	____	Thermofax copies	____	____	Thermofax copies	____	____	Thermofax copies
____	____	Microfilm	____	____	Microfilm	____	____	Microfilm

This is surely a pretty trivial matter if the info service is now as poor as we claim it is. The info is what counts.

27. Some searches require a very thorough search of specified sources covering certain periods of time. Others require a less thorough search. Once you have specified sources and period of time covered, what percent of these should be searched to be adequate? Is there a level below which is inadequate?

Adeq.	Inadeq.		Adeq.	Inadeq.		Adeq.	Inadeq.	
____	____	100%	____	____	100%	____	____	100%
____	____	90-99%	____	____	90-99%	____	____	90-99%
____	____	80-89%	____	____	80-89%	____	____	80-89%
____	____	70-79%	____	____	70-79%	____	____	70-79%
____	____	60-69%	____	____	60-69%	____	____	60-69%
____	____	50-59%	____	____	50-59%	____	____	50-59%
____	____	Below 50%	____	____	Below 50%	____	____	Below 50%

Is this question supposed to show loss % to tolerable?

28. Now I'd like you to make some comparisons between characteristics of document retrieval systems so that we will know which are the most important to you in your searches. These cards have been shuffled. First, sort them into three groups. Put those you feel are most important on your right, and those that are least important on your left, and the remainder in between. Now take those that are most important and put them into order of importance. Do the same with the other two stacks. (RECORD RANK ORDER.)

Order	Requirement	Order	Requirement	Order	Requirement
_____	1.	_____	1.	_____	1.
_____	2.	_____	2.	_____	2.
_____	3.	_____	3.	_____	3.
_____	4.	_____	4.	_____	4.
_____	5.	_____	5.	_____	5.
_____	6.	_____	6.	_____	6.
_____	7.	_____	7.	_____	7.
_____	8.	_____	8.	_____	8.
_____	9.	_____	9.	_____	9.
_____	10.	_____	10.	_____	10.

BACKGROUND INFORMATION

And now a few background questions.

1. Name _____

2. Company _____

3. What is your job title? _____

4. Would you classify yourself as a research manager, a member of the senior staff, or a member of the junior staff?

____ Research Manager
____ Senior staff
____ Junior staff

5. In terms of Civil Service classifications, which of the following comes closest to your job?

____ GS9
____ GS10
____ GS11
____ GS12
____ GS13
____ GS14

(NOTE: DESCRIPTION WILL BE GIVEN RESPONDENTS SO THEY CAN JUDGE. THE CIVIL SERVICE DOCUMENT HAS NOT BEEN RETRIEVED YET.)

6. Which one of the following do you work in mostly: (READ LIST)

____ Design
____ Development
____ Testing
etc.
etc.

7. In a general technical sense, what do you consider to be your specialty field? For example, computer design, microwave circuit and techniques, etc.

_____

8. What academic degree(s) do you hold and what year was it conferred?

Degree	Year conferred
____ BSEE	_____
____ MSEE	_____
____ Engineer	_____
____ PhD, ScD	_____
____ Other _____	_____

9. Are you a member of IRE or of AIEE? If so, what type of membership do you hold?

IRE	AIEE
___ Not a member	___ Not a member
___ Fellow	___ Fellow
___ Sr. Member	___ Member
___ Member	___ Associate
___ Associate	

10. How many years of working engineering experience have you had in these types of organizations? (READ LIST)

___ University
___ Research Institute
___ Industry
___ Government Labs or Offices
___ Independent Consulting

___ TOTAL

11. Have you authored any publications or given any technical papers in the last year? If so, how many of each of the following?

___ None
___ Technical articles
___ Books
___ Technical papers
___ Other_____

12. Into which of the following age groups do you fall? (READ LIST)

___ Under 25
___ 25 to 29
___ 30 to 34
___ 35 to 39
___ 40 to 44
___ 45 and over

CARD B

1. AERO/SPACE ENGINEERING
2. AMER INST ELEC ENG TRANS
3. AMER MATH SOC BULL
4. AMER MATH SOC NOTICES
5. AMER MATH SOC PROC
6. APPLIED MECHANICS REVIEWS
7. APPL SCIENCE & TECHNOLOGY INDX
8. APPLIED SCI RESEARCH SEC B
9. ASSN FOR COMPUTING MACH COMMUN
10. ASSN FOR COMPUTING MACH JOUR
11. ASTRONAUTICAL SCIENCES REVIEW
12. ASTRONAUTICS
13. ASTROPHYSICAL JOURNAL
14. AUDIO
15. AUTOMATIC CONTROL
16. AUTOMATIC DATA PROCESSING
17. AUTOMATION
18. AUTOMATION & REMOTE CONTROL
19. AVIATION WEEK
20. BELL LABORATORIES RECORD
21. BELL SYSTEM MONOGRAPHS
22. BELL SYSTEM TECHNICAL JOURNAL
23. BROWN BOVERI REVIEW
24. COMPUTER ABSTRACTS
25. COMPUTER JOURNAL
26. COMPUTERS & AUTOMATION
27. CONTROL
28. CONTROL ENGINEERING
29. DATA PROCESSING
30. DATA PROCESSING DIGEST
31. ELECTRICAL COMMUNICATION
32. ELECTRICAL DESIGN NEWS
33. ELECTRICAL ENGINEERING
34. ELECTRICAL MANUFACTURING
35. ELECTROMECHANICAL DESIGN
36. ELECTRONIC APPLICATIONS
37. ELECTRONIC DESIGN
38. ELECTRONIC ENGINEERING
39. ELECTRONIC INDUSTRIES
40. ELECTRONIC NEWS
41. ELECTRONIC TECHNOLOGY
42. ELECTRONICS
43. ELECTRONICS WORLD
44. ENGINEERING INDEX
45. I B M JOUR OF RES & DEVEL
46. I R E CONVENTION RECORD
47. I R E PROCEEDINGS
48. I R E TRANS PROF GROUPS
49. I S A JOURNAL
50. INDUSTRIAL ARTS INDEX
51. INFORMATION & CONTROL
52. INST OF NAVIGATION JOURNAL
53. INST OF ELEC ENG JOURNAL
54. INST OF ELEC ENG PROC A B C
55. INSTRUMENTATION
56. INSTRUMENTS & CONTROL SYSTEMS
57. INSTRUMENTS & EXP TECHNIQUES
58. INT J ABS STAT THEORY & METHOD
59. J AIR TRAFFIC CONTROL
60. J APPLIED PHYSICS
61. J ELECTRONICS & CONTROL
62. J GEOPHYSICAL RES
63. J MATH & PHYSICS
64. J THE ASTRONAUTICAL SCIENCES
65. MACHINE DESIGN
66. MANAGEMENT & BUS AUTOMATION
67. MARCONI REVIEW
68. MATERIALS IN DESIGN ENG
69. MATHEMATICAL REVIEWS
70. MATHEMATICS OF COMPUTATION
71. MICROWAVE JOURNAL
72. MISSILE DESIGN & DEVELOPMENT
73. MISSILES & ROCKETS
74. NAVIGATION
75. PHILIPS RESEARCH REPORTS
76. PHILIPS TECHNICAL REVIEW
77. PHYSICAL REVIEW
78. PHYSICS OF FLUIDS
79. PLANETARY & SPACE SCIENCE
80. POWER APPARATUS & SYSTEMS
81. PRODUCT ENGINEERING
82. Q S T
83. R C A REVIEW
84. RADIO AGE
85. RADIO-ELECTRONICS
86. RADIO ENGINEERING USSR
87. RADIO ENG & ELECTRONICS USSR
88. REV OF SCIENTIFIC INSTRUMENTS
89. REVIEWS OF MODERN PHYSICS
90. S I A M JOURNAL
91. SCIENCE
92. SCIENCE ABSTRACTS B ELEC ENG
93. SCIENTIFIC AMERICAN
94. SEMI-CONDUCTOR ELECTRONICS
95. SEMI-CONDUCTOR PRODUCTS
96. SIGNAL
97. SOC INSTRUMENT TECHNOL TRANS
98. SOC MOTION PICT & TELE ENG J
99. SOLID STATE ABSTRACTS
100. SOLID STATE ELECTRONICS
101. SOVIET MATHEMATICS-DOKLADY
102. SPACE/AERONAUTICS
103. SPERRY ENGINEERING REVIEW
104. SYLVANIA TECHNOLOGIST
105. SYSTEMS
106. TECHNICAL COMMUNICATIONS
107. TELECOMMUNICATIONS USSR
108. TELEVISION SOCIETY JOURNAL
109. TEST ENGINEERING
110. WESTERN UNION TECHNICAL REVIEW
111. WESTINGHOUSE ENGINEER
112. WIRELESS WORLD

Charley:

A very well written report. I have only a few general comments.

1. We seem in the report to disown the "performance-requirement matching with weighting" approach, yet it still occupies a significant portion of the text. Would we recommend its use? Would we defend it? I don't think so. Yet included very prominent attacks on the opinion sampling approach, so I tend to think you agree with me. Alright then, why do we include it at all. ~~I th~~ You might list it ~~under~~ as one of several misdirected starts on the problem and let it lie there.

2. The ~~word~~ phrase "minimum cost" occurs quite frequently when I think you really mean cost alone.

3. ~~The relationship between the system and its users~~ importance of the parsing of natural ~~language~~ is ~~not~~ emphasized several times, but it is not emphasized. Somehow you even toy with the idea of dissociating the user from the specific library. My personal feeling is that any evaluation will have to be of the system-user pair and not one or the other component separately. This is a sufficiently important point that it should appear in the Summary & Conclusions. I.e. we cannot evaluate the Western Reserve thing unless we know who will use it. I think you should gather all of the evidence you have on this point and consolidate it into ~~a section~~ one paragraph.

4. The definition of model and its use is overly long and takes on the tone of an O.R. lecture. I had the impression you were talking down to your readers.

Team Comments on 2nd Draft Questionnaire.

Aug 30, 1961.

Research activities for which Information Requirements needed.

Choose 3 in which most time spent:

1. Writing technical proposals,
2. General project planning,
3. Theoretical design of experiments,
4. Physical design of equipment,
5. Correlation of experimental results with theory or vv,
6. Formal literature search,
7. Search for novel technical ideas on which to base new projects or ~~research~~ new research,
8. Communication with oneself over time – leaving trails that may later be followed if needed.

Aug 30, 1961

Requirements For Document Retrieval.

Interview Questions:

1. Urgency Curve (amt of return vs. time)
2. Effort Curve (return vs. effort.)
3. Currency curve (currency vs effort.)
4. % of search time spent on culling irrelevant documents.
5. Hours per interesting document (search time) — for informative reading.
6. Do you often? ever? want high assurance that a document on a subject does NOT exist?
7. Tolerable wasted effort in search before new tack is tried

SRI is conducting a study for NSF to develop methods for evaluating the performances of document retrieval systems. A critical part of the study is the determination of whether the needs of users are met. In this connection we are trying to develop measures of the document needs of researches in the electronics field.

Let me give you definitions for two terms I'll be using throught this interview. First, I'll be concerned with document retrieval--that is, entire documents, or references to documents. I am not concerned with information retrieval --that is, the retrieval of specific facts. Second, I'll use the word search to mean looking for references and/or documents on a given subject. An example of a search is a request, made through a library, for documents describing the use of transistors in certain kinds of electronic devices. Not included as requests for specific documents which you know deal with the subject. For example, you are not searching when you ask the library to send you some issue of the IRE proceedings.

Q1 Does the respondent make searches?

Keeping this last distinction in mind, could you tell me, in your own words, whether you conduct, or cause to be conducted, literature searches, and about how often you do this.

A. We must first determine whether the man we are questioning should be included in the sample. If he does not perform searches, we should immediately skip to the BACKGROUND INFORMATION section and end the interview. I think we want a qualitative reply to this question. Our intention here is not so much to measure frequency of use as to eliminate the "rare" and "infrequent" users.

I'm not sure we want a quantitative answer, because this would require a judgement about the quality of the searches, e.g., putting relative weights on extremely important searches which directly effect the success of a project vs searches for references which are used in proposals.

B. If the respondent cannot answer this question, his other replies are probably worthless. I anticipate that the answers will be of the "sometimes", "not very often", form. The interviewer can ask for a more specific reply; e.g., about once a month.

Q2 For many of the remaining questions I'll ask, I want you to recall a specific search you made--perhaps the last one or one that was particularly important to your work. I will be asking somewhat detailed questions about this particular search. Can you remember such an incident?

A. I feel that asking a respondent specific questions about the general act of searching can only illicit vague replies. Such answers are useless to us. Hence, it is important to determine immediately whether the respondent recalls any search he conducted. If he cannot, then once again, there is little point in prolonging the interview. I can summarize the intent of this and the preceding questions as follows:

		Frequency		
		High	Low	Nil
Recollection	Good	✓	✓	
	Bad			

We want respondents who have good recollection and who have conducted searches. The fact that a respondent does a lot of searching is not enough.

B. See A.

Q3 For the particular search, can you remember what activity you were engaged in at the time. By activity I mean such things as

(show Card A*)

It's possible you know these activities by other names or, perhaps, the activity you were engaged is not shown.

A. The answer will tell us what activity generated the search. Note that I am <u>not</u> interested in his knowing how much time this activity consumes. The latter gives us little usable information.

B. Providing the activities are ~~virtually~~ mutually exclusive, or reasonably so, this question can be answered.

Q4 Do you recall how urgently you needed the results at the time you requested the search. Try for the moment to forget the importance of the results--we will get to this shortly. I am interested now in knowing how important the search seemed to you at the time.

___Very urgent; other work held up. E.g., a search for information on the characteristics of a substance to be used in a current experiment.

___Important; helps determined course of future work. E.g., a search for information on the performance of one of a class of possible circuits to be used in a piece of equipment.

___Interesting; helped fill in gaps in your knowledge. E.g., the derivation of a formula used in a report.

___Little priority; completions of search results not very important. E.g., a bibliography to be used in a proposal.

A. In this question I attempt to get at the urgency of the search. The next question gets information about the subsequent importance of the search results. This may be a fine (unnecessary?) distinction, but they are separate characteristics.

B. If respondent remembers anything about a search, it probably is the urgency of the request. I suggest four categories, because I could illustrate each with a specific example, and the differences seemed meaningful. I suspect that some categories would force the answers. An argument can be made for one less category--i.e., combine the second and third.

Q5 In this question I would like to know how important the search results were to you. ~~If~~ It sometimes happnns that a routine library search, turns up significant information, while conversely, an urgently requested search, sometimes adds little new to the searcher's knowledge. In the case of the particular search we have been discussing, which would you say is true--

___Very important; E.g., changed the course of a project, a provided key information needed to obtain a contract.

___Not very important. E.g., results were used as supplementary or back-up material.

___Unimportant; E.g., results had little or no effect on course of work.

A. As indicated in Q4 I am trying to distinquish between urgency and importance. Again, there is a question of number of categories. The suggested ones are mutually exclusive and do provide enough usable categories.

B. If the respondent cannot answer this question; i.e., does not know what he did with the results, there is no chance the respondent can tell us anything about its contents of the ~~-8-~~ search.

In the sample questionnaire I have described (A) the reason for asking each question and (B) the likelihood that the question can be answered to our satisfaction. The two criteria are indicated immediately after each potential question. Essentially, the questions ask:

I Is the respondent qualified to complete the questionnaire

Q1 Does the respondent make searches

Q2 Can the respondent remember a spedfic search

II Circumstances surrounding the search

Q3 What was the respondent doing when he made the search?

Q4 How urgent was the search to the respondent?

Q5 How important were the search results?

III Technical characteristics of respondents library

Q6 Who conducted the search (present question 11)

Q7 What library facilities were used (present question 15)

Q8 Form of the search request (present question 21)

Q9 Form of the search results (present questions 25-26)

IV Technical characteristics of search results

Q10 Elapsed time before results received (revision of present question 22)

Q11 Currency of results (revision of present question 23)

V Ranking of the primary characteristics of retrieval systems. Including explanation of the interaction and conflicts ⊬ among retrieval system characteristics

VI Background Information--

Exceptions: For question 5, substitute salary ranges

In question 8, ask for highest academic degree

Ranking of primary characteristics of retrieval systems.

I am going to show you 10 cards each of which contains a statement about a performance measure by which retrieval systems can be judged. It is important to realize that these measures are to a degree in conflict with one another. For example, if you want your requests satisfied as quickly as possible, you normally must expect that some relevant material will be overlooked. Similarly, if you want the system to produce all or nearly all the relevant documents then you must expect a large number of irrelevant material--"false drops"--in the results.

The cards state the primary conflicts that exist, and I want you to sort the cards into ___ piles (containing respectively ___ cards) from the most important to the least important performance measure. Naturally, this sorting will depend, to some extent, on the type and urgency of the search. Therefore, I would like you to sort the cards as you would for an urgent search.

Critique of questions 22, 23, 24 and 27.

These questions reflect our ignorance of what we are after. In them we ask for an opinion about 1. the adequate amount of elapsed time between request and result (question 22); 2. the currentry of its material in the file (question 23); 3. the number of false drops in the results (question 24); and 4. the relevancy of the search products (question 27).

I/ [illegible]

I have two questions:

1. Since the respondent has not been appraised of the conflicts involved in simultaneously maximizing all performance measures, what prevents him from requiring that search results be (1) available immediately (2) be up-to-the minute (3) have no false drops and (4) certain all relevant material. After all he is not building the retrieval system, nor paying for it, he merely uses it, therefore why shouldn't he ask for perfect performance.

2. The performance I expect from a library depends on the urgency of my needs. In these questions we have not specified, nor even implied, the level of urgency the respondent should have in mind. Either we specify a hypothetical, standard situation, or we ask that the answers apply to the last search he conducted (asking in another question the urgency of that search).

We are interested in your needs for completeness of coverage (no. of sources, and period of time covered) in searching. Ignore the fact that you may not be able to do these searches with present tools, and indicate when you could have used a search of the various degrees of completeness shown below.

For the last 5 years of publication:	I often need a search of this ~~kind~~ body of material	Once in a while I have a need for a search of this body of material	I haven't had a need to search this body of material yet
The contents of 15 or less journals of special interest to you	_____	_____	_____
The contents of all the journals covered by the major indexing & abstracting services in ~~this~~ your field	_____	_____	_____
The contents of all the U.S. scientific & technical journals	_____	_____	_____
The contents of all English speaking scientific and technical journals	_____	_____	_____
The contents of all the world's scientific & technical journals	_____	_____	_____

How would your answers differ if you were not restricted to searching to the last 5 years of publication?

Question 19a. And now a general question about your needs for coverage - that is, the number of sources and ~~xxix~~ period of time covered - for all the kinds of searches you have done in the past few years. How often could you have used these types of searches, ignoring the fact that you may have been unable to do these searches with current tools?

	Often	Once in Awhile	Never	No Answer
The contents of 15 or less journals of special interest to you	83%	16	—	2
The contents of all the journals covered by the major indexing & abstracting services in your field	79%	68	1	2
The contents of all the U. S. scientific & technical journals	97%	80	9	2
The contents of all the world's scientific & technical journals	14%	69	15	2

Note: Going across the page, the total in all instances is 100% and the base is 92.

Question 21. Company name.

Stanford Research Institute	24%
Lockheed	17
Sylvania	24
IBM	20
Total Base	100% (92)

Note: Data do not include 2 individuals who performed no searches.

Question 23. Would you classify yourself as a research manager, a senior engineer, an engineer, or a junior engineer?

Research Manager	18%
Senior engineer	49
Engineer	23
Junior engineer	4
No answer	1
Total	100%
Base	(92)

Note: Data do not include 2 individuals who had performed no searches.

Question 25. What is the highest academic degree you hold and what year was it conferred?

Degree	
BSEE	39%
MSEE	36
Engineer	8
PhD, ScD	15
~~Other~~	
No answer	-
Total	100%
Base	(92)

Year conferred	
1959 - 1961	28%
1954 - 1958	29
1953 or earlier	43
No answer	—
Total	100%
Base	(92)

Note: Data do not include 2 individuals who had performed no searches.

Question 26. Are you a member of IRE or of AIEE? If so, what type of membership do you hold?

IRE

Not a member	27%
Fellow	-
Senior member	12
Member	51
Associate	2
Student member	1
No answer	-
Total	100%
Base	(92)

AIEE

Not a member	89%
Fellow	-
Member	5
Associate	5
No answer	1
Total	100%
Base	(92)

Note: Data do not include 2 individuals who had performed no searches.

Question 27. How many years of working engineering experience have you had in these types of organizations?

Total Experience

5 years or less	25%
6 - 10 years	35
11 years or more	40
No answer	-
Total	100%
Base	(92)

Note: Data do not include 2 individuals who had performed no searches.

Question 28. Have you authored any publications or given any technical papers in the last three years? If so, how many technical ~~xx~~ articles or papers? Any books? Anything else?

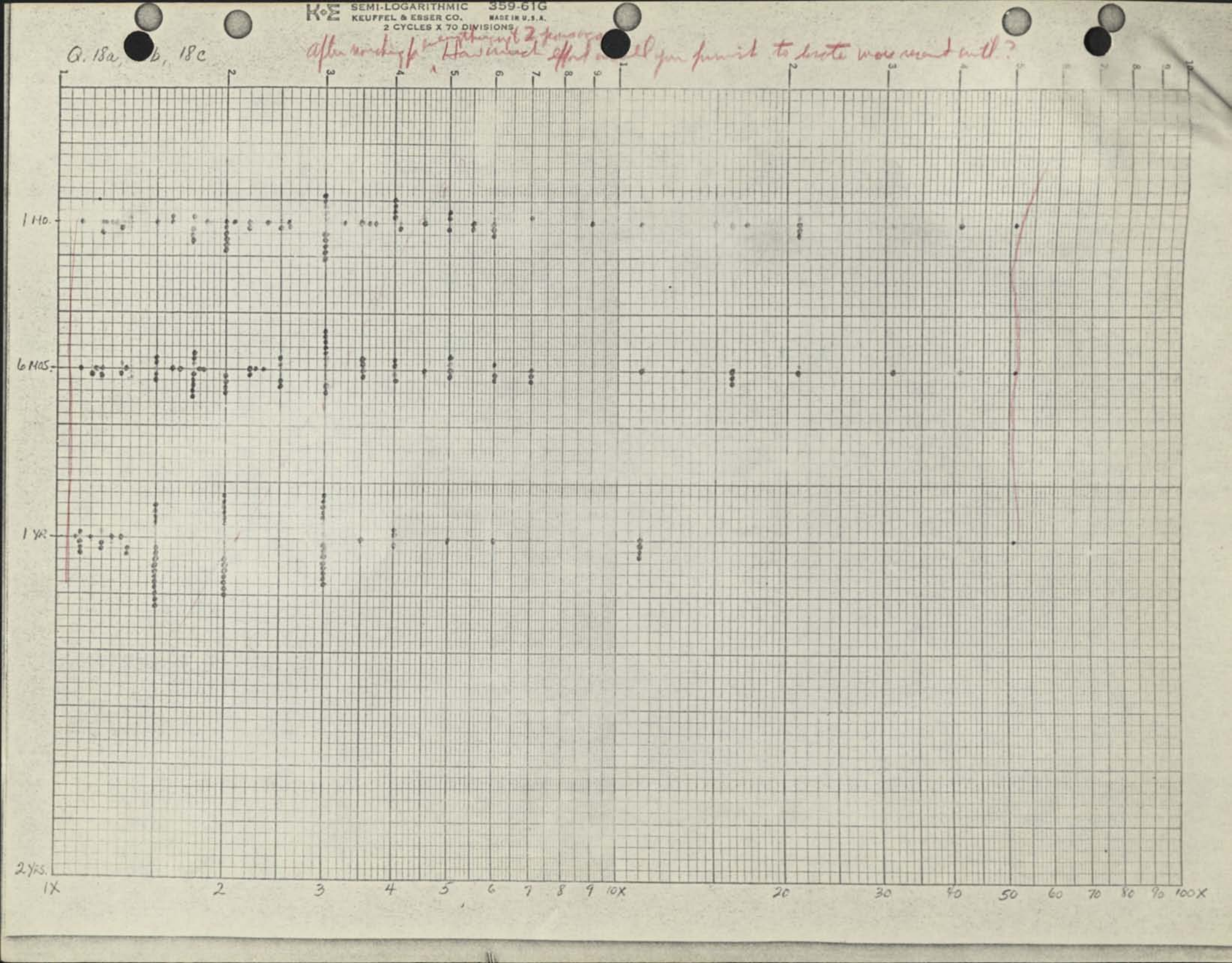
Total Publications:	
None	51%
One	14
Two	12
Three to five	14
Six or more	9
No answer	-
Total	100%
Base	(92)

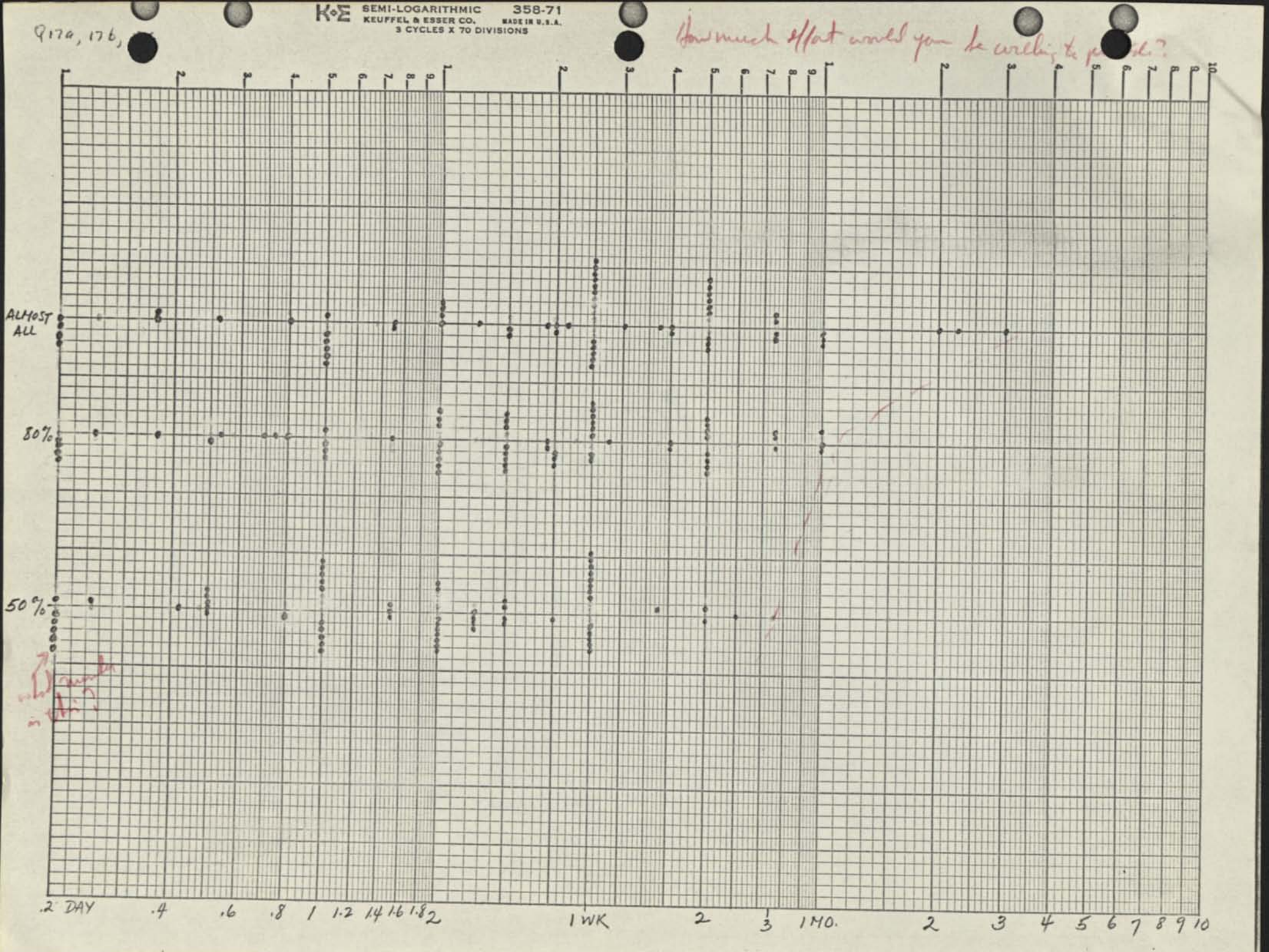
Note: Data do not include 2 individuals who had performed no searches.

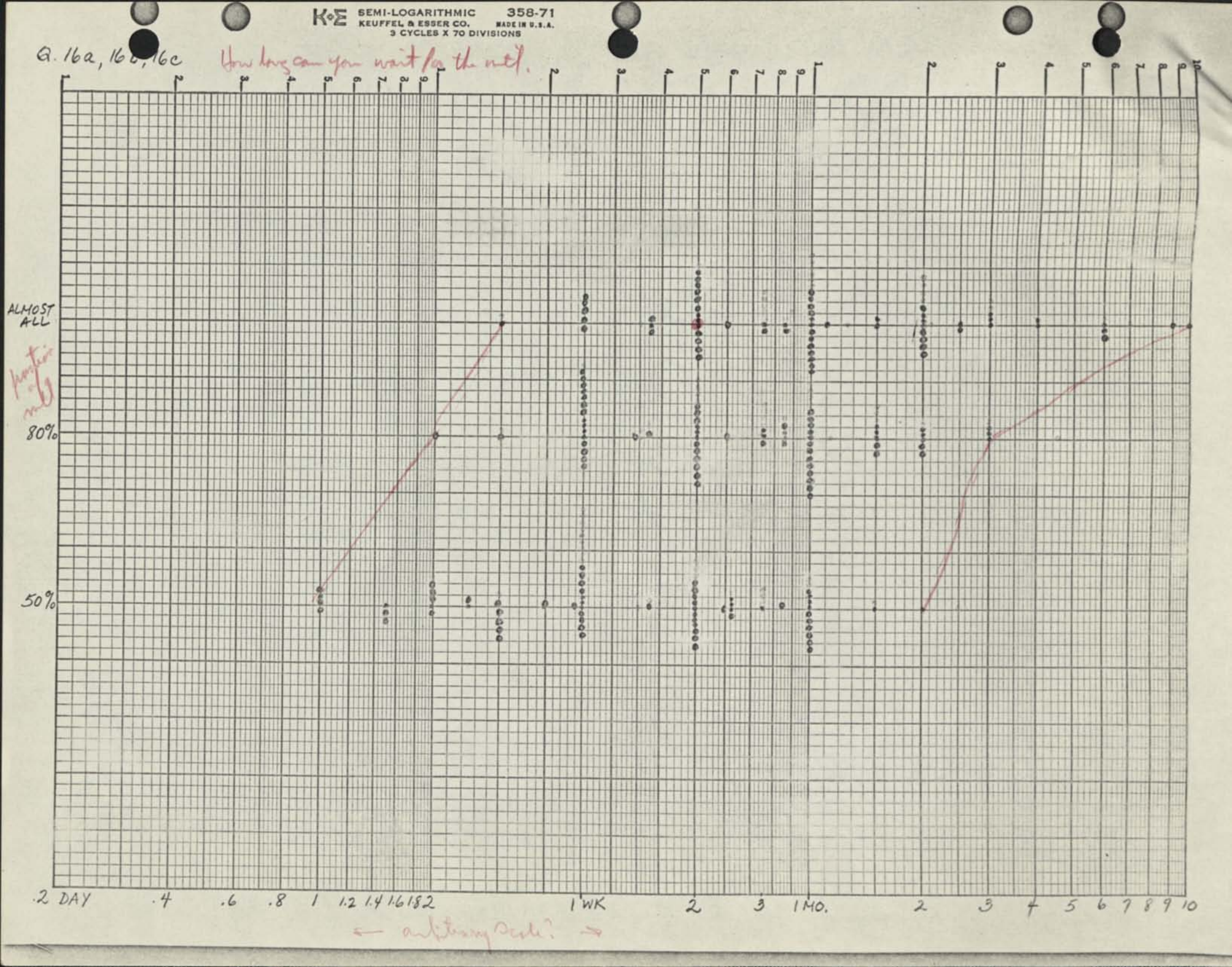
Question 29. Into which of the following age groups do you fall?

Under 25	1 %
25 - 29	23
30 - 34	30
35 - 39	26
40 - 44	17
45 and over	3
No answer	—
Total	100 %
Base	(92)

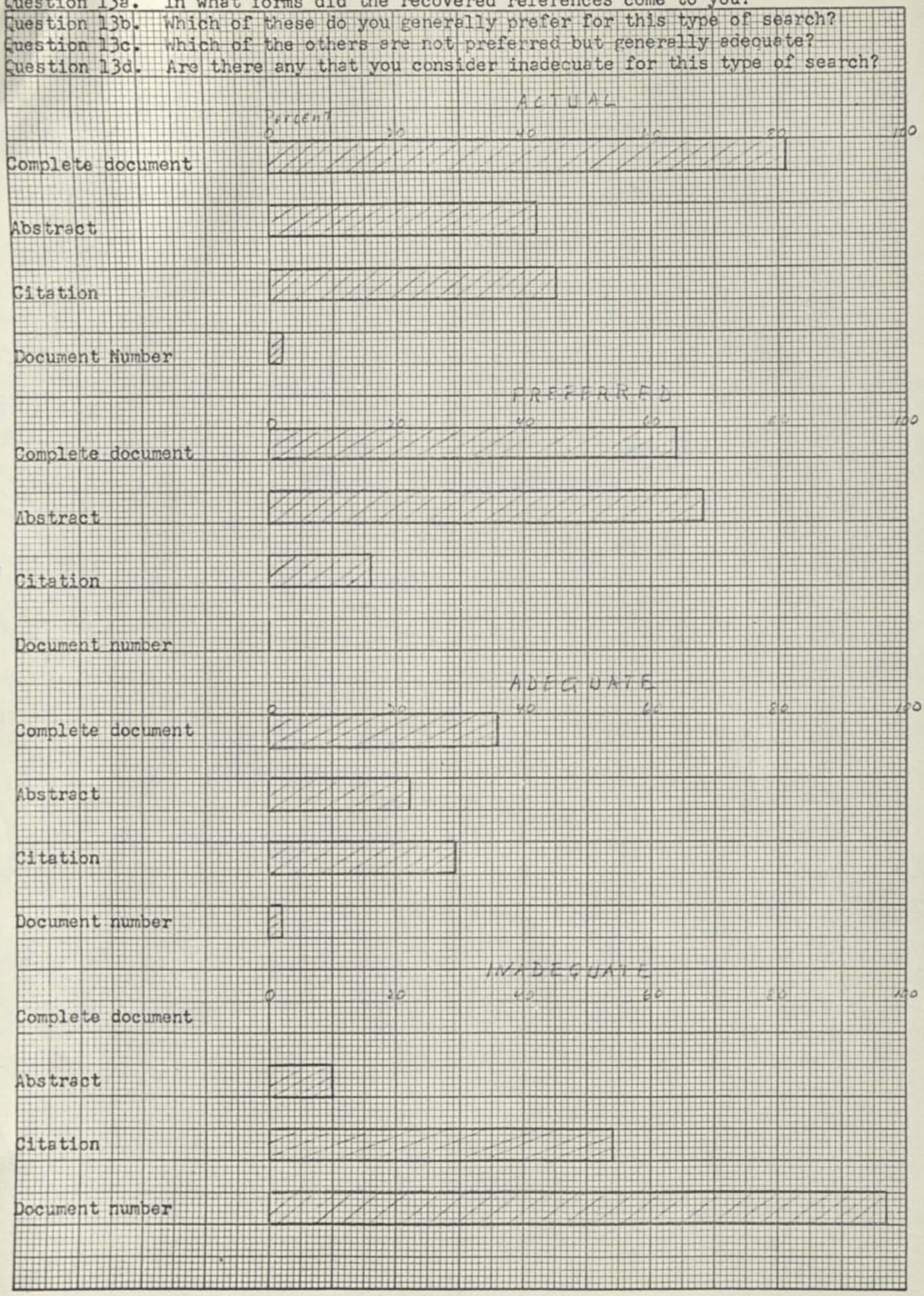
Note. Data do not include 2 individuals who had performed no searches.


K·E SEMI-LOGARITHMIC 359-61G
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 70 DIVISIONS
Q. 18a, b, 18c
1 MO.
6 MOS.
1 YR.
2 YRS.
1X
2
3
4
5
6
7
8
9
10X
20
30
40
50
60
70
80
90
100X


K·E SEMI-LOGARITHMIC 358-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS
Q17a, 17b,
How much effort would you be willing to put forth?
ALMOST ALL
80%
50%
.2 DAY
.4
.6
.8
1
1.2
1.4
1.6
1.8
2
1 WK
2
3
1 MO.
2
3
4
5
6
7
8
9
10


K·E SEMI-LOGARITHMIC 358-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS
Q. 16a, 16b, 16c
How long can you wait for the net.
ALMOST ALL
80%
50%
.2 DAY
.4
.6
.8
1
1.2
1.4
1.6
1.8
2
1 WK
2
3
1 MO.
2
3
4
5
6
7
8
9
10
← arbitrary scale? →

Question 13a. In what forms did the recovered references come to you?
Question 13b. Which of these do you generally prefer for this type of search?
Question 13c. Which of the others are not preferred but generally adequate?
Question 13d. Are there any that you consider inadequate for this type of search?



"No Answer" Not Shown

Question 15. (Abbreviated form of question follows.) Please rank these items in the order in which you would least want to compromise on the type of search we've been discussing.

total ranking → 1 7 2 4 5 6 3

Criteria

7 1 6 4 3 2 5

Rank	A	B	C	D	E	F	G
1	39%	6%	20%	11%	7%	10%	11%
2	17	6	18	16	21	5	14
3	15	8	25	13	13	4	17
4	22	10	13	15	12	16	15
5	3	15	13	17	19	14	20
6	2	33	9	11	13	19	14
7	2	22	2	15	16	31	9
N. A.	–	–	–	–	–	–	–
Total Base	100% (92)	100% (92)	100% (92)	100% (92)	100% (92)	100% (92)	100% (92)

Note: On this table, a rank of 1.5 would show as 1, a rank of 2.5 would show as 2, etc. More precise rankings are given elsewhere.

SURVEY DATA

1. NAME: DATE:

2. ORGANIZATION: SRI
Other (which one?)

3. JOB TITLE: Research Engineer
Sr. Research Engineer
Other (describe)

4. ACADEMIC TITLE: (type &date) B.S.E.E.
M.S.E.E.
Engineer
Ph.D.
Sc. d.
Other (describe)

5. IRE STATUS: Fellow
Sr. Member
Member
Associate
Non-member

6. AIEE STATUS: Fellow
Member
Associate
Non-member

7. YEARS OF WORKING ENGINEERING EXPERIENCE IN DIFFERENT TYPES OF ENGINEERING ORGANIZATIONS:

University
Research Institute
Industry
Government Labs or Offices
Independent Consulting

8. In a general technical sense, what do you consider to be your specialty field? (e.g. computer design, microwave circuit and techniques, radio propagation, navigation aids, audio systems).

SURVEY QUESTIONS

1. What small group or "core" of technical publications are most useful to you in your work? (list 5 to 10 publications. The attached list may speed up the note taking.)

2. What publications might account for the great majority, say 90 to 95% of what you feel is the important technical literature of your specialty field? (e.g. journals, conference proceedings, abstract journals, etc.) That is, what publications are critically important to your work and should be maintained in a central reference service? (The attached list may speed up the note taking. List the indicated numbers and any others that you think should be included.)

3. Assume that in response to your search report, an information system could supply you with either of several different forms of information about the relevant references; (1) a reference number; (2) a complete citation of a paper; (3) an abstract; (4) a complete reprint of the original text. If the system could supply any of these four items at your option, how would you rate the desirability of each of these products? (Use a scale of numbers 0 to 10, with 0 defined as completely undesirable and 10 defined as most desirable.)

Rating of the Desirability of This Type of Product as the Immediate Result of the Search	Type of Product Resulting from the Search	Example
	reference number	AD-212 430
	citation	"Digital Data Communication Techniques," J.M. Wier, IRE Proc. Vol.49,No.1 pp.196-209 (January 1961)
	Abstract	"The majority of digital..."
	complete reprint of text	(no example necessary)

4. If the system response time is defined as the total time taken from the instant that the user makes his request known, to the instant that the request has been fulfilled, what fraction of your search needs (for a comprehensive search) actually require the different ranges of response times indicated below? (for example, 50% of the time I can only wait 1 hour or less, and the rest of the time might be evenly divided among the ~~6~~ remaining 8 ranges.)

Intervals of Tolerable Response Times	Fraction of Total Search Needs (in %)
1 hour or less	
between 1 and 4 hours	
between 4 hours and 1 day	
between 1 day and 3 days	
between 3 days and 1 week	
between 1 week and 2 weeks	
between 2 weeks and 1 month	
between 1 month and 6 weeks	
between 6 weeks and 2 months	
two months or more	
TOTAL	(should be 100%)

5. What fraction of your search needs could be answered to your satisfaction by a search of the different size files shown below? (For example, what fraction of your searches can be satisfied by only an examination of the entire world's literature, what fraction can be satisfied by the search of the back issues of a single journal and so on)

Different Size Files to be Searched	Fraction of Total Search Needs (in %)
5 years back issues of 1 journal (name the journal)	
5 years back issues of the "core publications" listed in question #1.)	
5 years back issues of all U.S. journals in your specialty field	
5 years back issues of all U.S. scientific journals	
5 years back issues of all U.S. scientific journals and ASTIA	
5 years back issues of the world's scientific literature	
TOTAL	(should be 100%)

Any specific comments? (for example, "90% of my searches are satisfied by scanning the IRE and ACM publications.")

6. With most information systems, the inquiror will receive some responses, say abstracts,--some of which are directly relevant to his inquiry and some of which are only partially relevant, and some of which are completely irrelevant. How much completely irrelevant material would you normally tolerate as part of the search result (expressed as the ratio of completely irrelevant material to total material resulting from the search)?

7. Because of such things as indexing problems and incompleteness of file material, some available information may be overlooked or by-passed during a search operation. How much relevant material can you tolerate being overlooked or by-passed during the search (expressed as the ratio of relevant material overlooked to the total relevant material)?

8. a) What is the likelihood of your tolerating each of the various ranges of project costs below, to obtain a comprehensive literature search of a single specialty field?

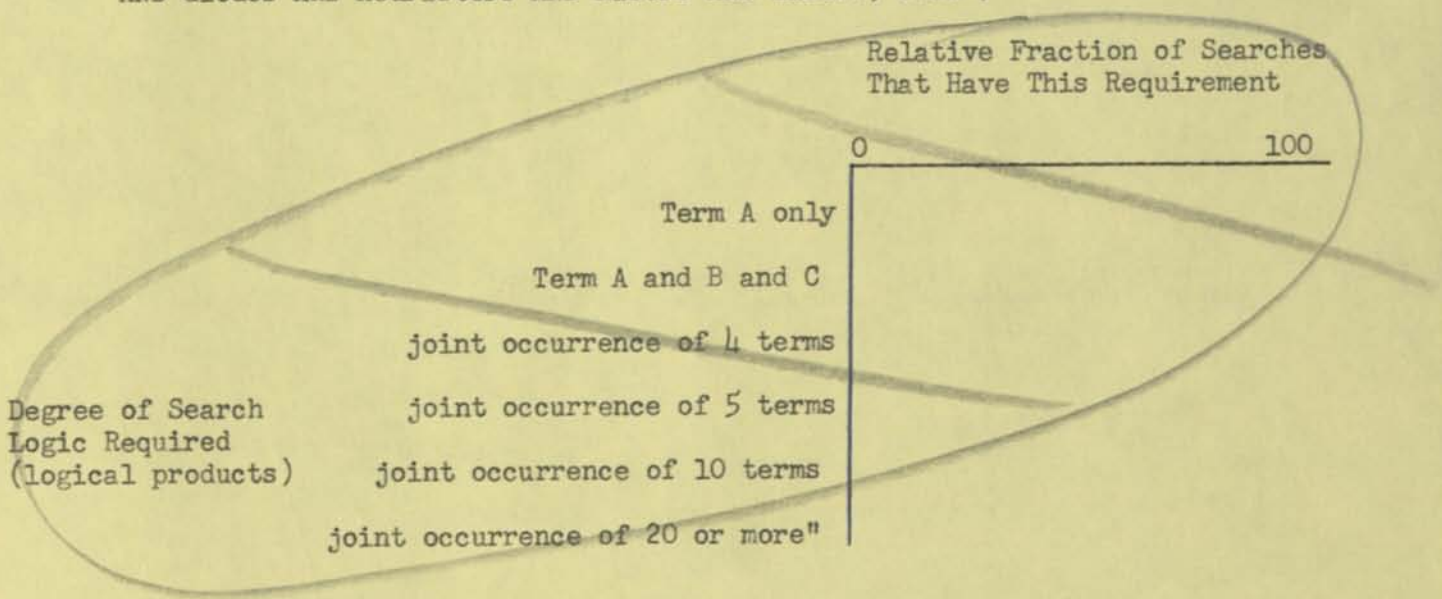
Tolerable Cost per Search (dollars)	Probability of Tolerating This Cost (In %)
1 dollar or less	
between 1 dollar and 10 dollars	
between 10 dollars and 100 dollars	
between 100 dollars and 200 dollars	
between 200 dollars and 500 dollars	
between 500 dollars and 1,000 dollars	
between 1,000 dollars and 5,000 dollars	
between 5,000 dollars and 10,000 dollars	

b) Have you ever served in the capacity of a project or task leader, or other responsible position where you were responsible for the financial and technical status of a project?

9. From a search logic standpoint, what fraction of your searches based on alternative occurrences of terms can be satisfied by a search based on a simple term or concept (e.g. transistors); by the search for either of two terms (e.g. transistors OR diodes);....by the search for any of five terms (e.g. transistors OR diodes OR neuristors OR masters OR lasers) ....etc.? Another way to pose the question would be to ask how many different alternative descriptive words appear in your search specification?

Degree of Question Complexity	Fraction of the Searches That Have This Requirement (in %)
Term A only	
Term A or B or C	
Any of four terms	
Any of five terms	
Any of ten terms	
Any of 20 or more terms	
TOTAL	_____ (should be 100%)

10. From a search logic standpoint, what fraction of your searches based on joint occurrences of terms is satisfied by a search based on the joint occurrence of two terms or concepts (e.g. transistors AND diodes);....by the search based on the joint occurrence of five terms (e.g. transistors AND diodes AND neuristors AND masers AND lasers) etc. ?



Degree of Question Complexity	Fraction of the Searches that Have This Requirement (in %)
Term A only	
Term A and B	
Term A and B and C	
joint occurrence of 4 terms	
joint occurrence of 5 terms	
joint occurrence of 10 terms	
joint occurrence of 20 or more terms	
TOTAL	_____ % (should be 100%)

11. For a comprehensive information searching system, what is the desirability of including references for each of the following types of technical information in the system? Rate each type with a number in the range of 0 to 100. Zero is defined as completely undesirable, and 100 is the most desirable.

Type of Information	Rating of the Desirability of Including This Type of Information in the System
journal articles	
conference proceedings articles	
unpublished conference presentations	
letters to the editor	
specific tables (e.g. complicated math functions)	
errata and corrections	
Book reviews	
article reviews	
editorials or comments from the editor	
requests for proposals	
announcement of contract awards	
new product announcements	
notices about personalities and their relocations, etc.	
news briefs (one or two paragraphs each)	
calendar of coming events and author deadlines	
military specifications	
vendors and their equipment or services	
biographies of personnel working in special fields	
descriptions of organizations working in special fields	
description of current R&D being performed by all other DOD contractors	
advertising index	
others?	

12. What relative degrees of restrictions could you tolerate in communicating with the search system? Rate each statement with a number in the range of 0 to 10 to indicate your degree of acceptance of such a situation. Zero is defined as completely unacceptable, while 10 is defined as most acceptable.

Rating of Degree of Acceptance of this Situation	Inquiror-System Communication Restrictions
	Inquiror speaks directly to the system in normal conversational manner and receives a response directly from the system.
	Inquiror speaks directly to a librarian who relays the conversation to the system, and returns the selected information to the inquiror.
	Inquiror frames his questions only with allowable subject headings or descriptors chosen from a master list of terms, and then communicates directly with the system.
	Inquiror speaks directly to a librarian, who in turn frames his questions only with allowable terms, communicates with the system, and returns the selected information to the inquiror.
	Inquiror frames his questions only in a specified abstract and symbolic programming language (similar to computer programming), transmits the request to the system in this language, and then receives the selected information in normal forms.
	Inquiror speaks directly to a librarian, who in turn frames his question in the specified abstract and symbolic programming language, communicates with the system, and returns the selected information to the inquiror.

13. Assuming that an abstract is the type of product produced by the search system, what is your relative degree of acceptance of the different types of output medium that might be provided by the system in response to your inquiry? Rate each media with a number in the range 0 to 10 to indicate your degree of acceptance of such a media. Zero is defined as completely unacceptable, while 10 is defined as most acceptable.

Rating Degree of Acceptance	Output Media
	A new impression of the original abstract (e.g. IBM printing, Flexowriter printing)
	Full-size letterpress reprint of the original abstract
	Full-size Ditto or other spirit copy of the original abstract
	Full-size Thermofax or other heat-developed copy of the original abstract
	Full-size Verifax or other chemical-developed copy of the original abstract
	Full-size Zerographic copies of the original abstract
	Half-size reductions of any of the above medias
	Individual microfilm chips for each abstract; requiring a microfilm viewer for reading or full-size printing.
	A single roll of microfilm record of the collection of selected abstracts; requiring a microfilm viewer for reading or full-size printing.
	Individual opaques microcards for each abstract; requiring a microfilm viewer for reading or full-size printing.
	A single opaque microcard record of the collection of selected abstracts; requiring a microfilm viewer for reading or full-size printing.
	Audio recordings of the selected abstracts.
	Individual microfilm chips, mounted in an aperture card; requiring a microfilm viewer for reading or full-size printing
	Other?

14. For a comprehensive information searching system, what is your feeling of the relative importance (to your work) of the following system characteristics? Rate each characteristic with a number in the range of 0 to 10. Zero is defined as the least important, and 10 is defined as the most important.

Rating of the Relative Importance of These System Characteristics	System Characteristics
	Type of information product (citation, abstract, etc.)
	System response time
	Size of file which can be searched
	Percent of irrelevant material produced
	Percent of relevant material overlooked
	Initial and Operating Cost
	Complexity of Search Logic Provided
	Restrictions and complexity of man-machine communications
	Output media (microfilm, full-size copies, etc.)
	Other?

1. TIME REQUIRED TO GET FINAL RELEVANT REFERENCES

2. TIME REQUIRED TO GET FIRST RELEVANT REFERENCES

3. PROPORTION OF IRRELEVANT MATERIAL PRODUCED BY SEARCH

4. AMOUNT OF RELEVANT MATERIAL OVERLOOKED

5. AUTOMATIC REMOVAL OF REDUNDANT, OR DUPLICATE, MATERIAL

6. AUTOMATIC REMOVAL OF OBSOLETE MATERIAL

7. AMOUNT OF TIME REQUIRED TO ENTER NEW AND RECENT INFORMATION INTO SYSTEM

8. FILE SIZE - THE NUMBER OF SOURCES AND PERIOD OF TIME COVERED.

9. TYPE OF REPRODUCTION GIVEN YOU - (FULL-SIZE LETTERPRESS REPRINT, THERMOFAX COPY, VERIFAX COPY, MICROFILM, ETC.)

10. TYPE OF SEARCH PRODUCT - THAT IS, WHETHER A REPRINT, AN ABSTRACT, A CITATION, OR A DOCUMENT NUMBER IS GIVEN TO YOU

11. EASE OF YOUR COMMUNICATION WITH SYSTEM (- CODES WORDS USED TO INITIATE SEARCH, ETC.)

$\binom{N}{2}$ pair-wise comparison

N	No. comparisons
3	3
4	6
5	10
6	15
7	21
8	28
9	36
10	45
11	55
12	66

Question 12d: How old was the most recent reference turned up [illegible] ?
In other words, how recent was the material [illegible] ?

12e: Was this easy to or did you [illegible]

Percent

80

60

40

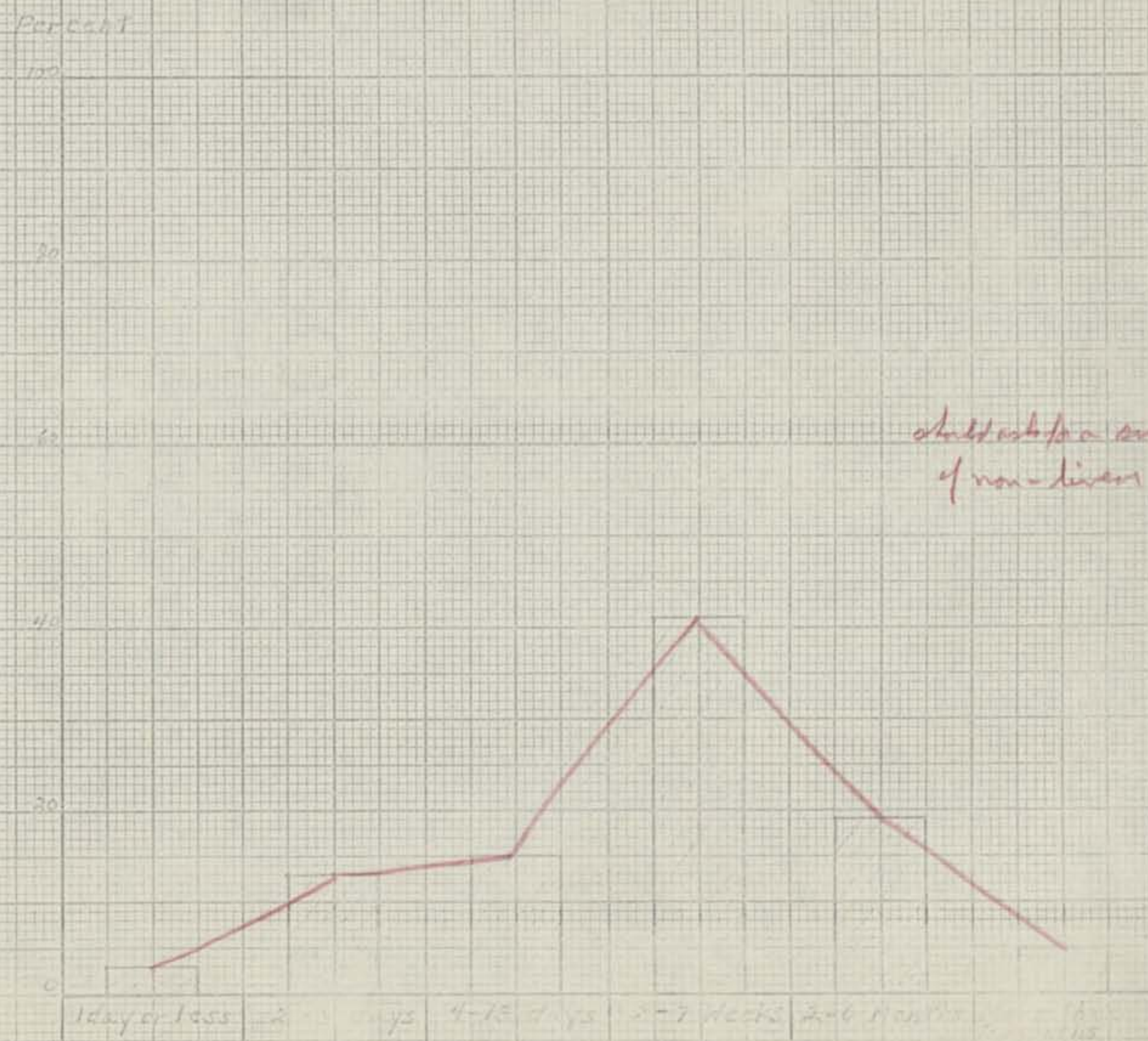
20

a b

Under 3 Months | 3-6 Months | 6 Months-1 Year | 1-2 years | Over 2 years | Over 10 years

"No Answer" Not Shown

Question IIC: What was the maximum amount of time you could have waited for the major group of relevant references?



should ask for a single number instead of a choice of non-linear segments.

"No Answer" Not Shown

Question:

11a: Approximately how long was it from the time you made your request until you had received the major group of relevant references?

11b: Was this adequate or did you really need the material sooner?

Percent

100

75

50

25

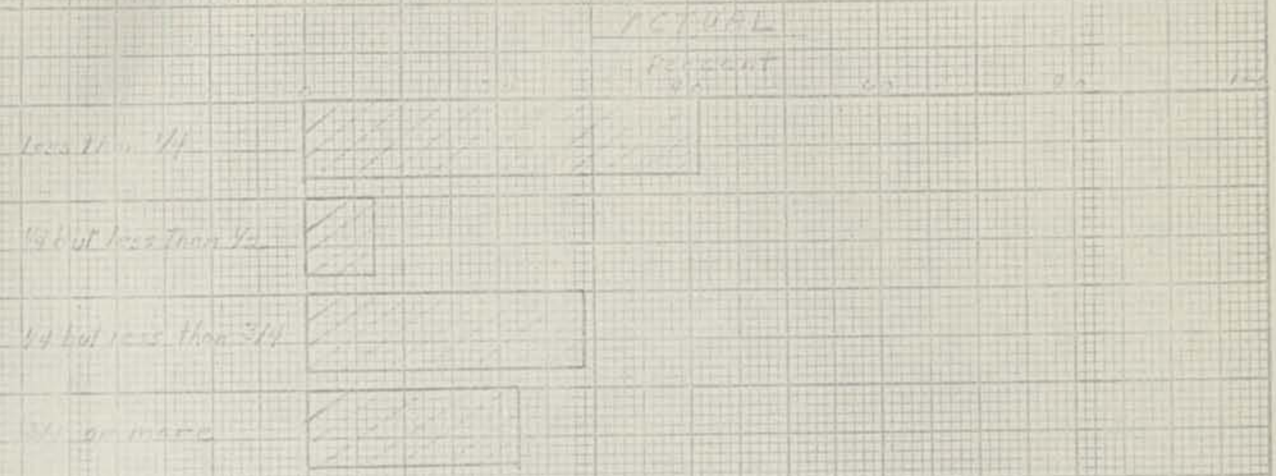
0

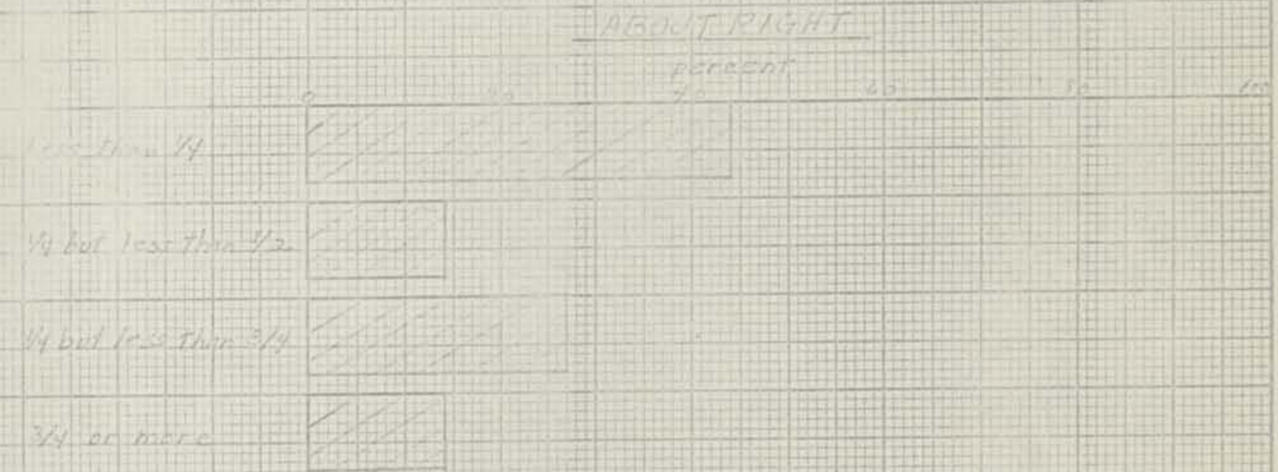
"No Answer" Not Shown

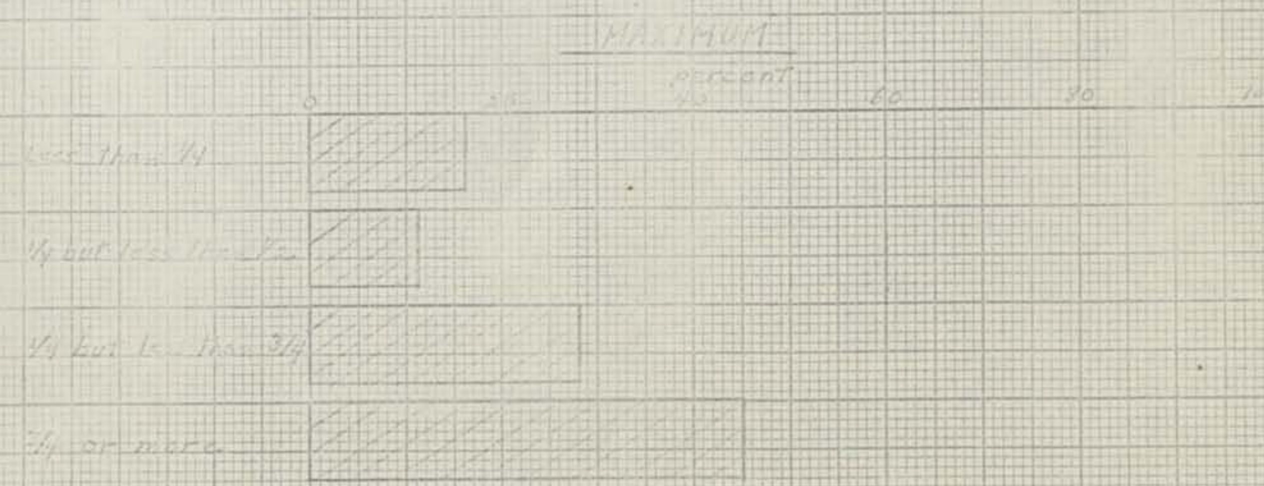
Question 14a: Some irrelevant material is usually turned up in a search. What proportion of the total time you spent on this search would you guess was spent in culling out irrelevant or duplicate material?

14b: Is that about right or should you have had to spend less of your time culling out irrelevant or duplicate material?

14c: Of the time you spend on the search what is the maximum proportion of your time you would be willing to spend culling out irrelevant material?

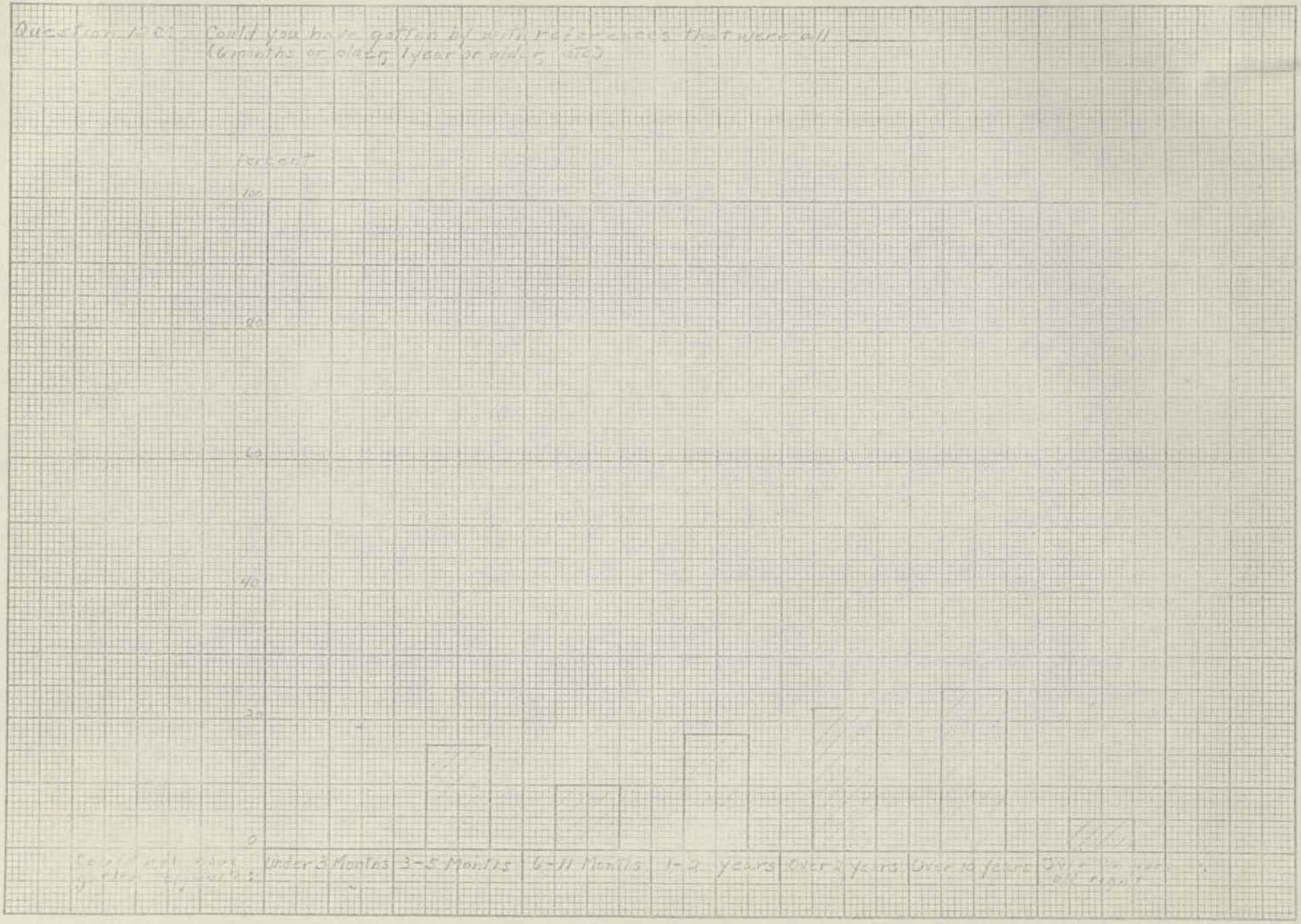






"No Answer" Not Shown

Question 1 c: Could you have gotten by with references that were all (6 months or older, 1 year or older, etc.)



Question 2: Have you or anyone requested by you conducted any research in the last year?

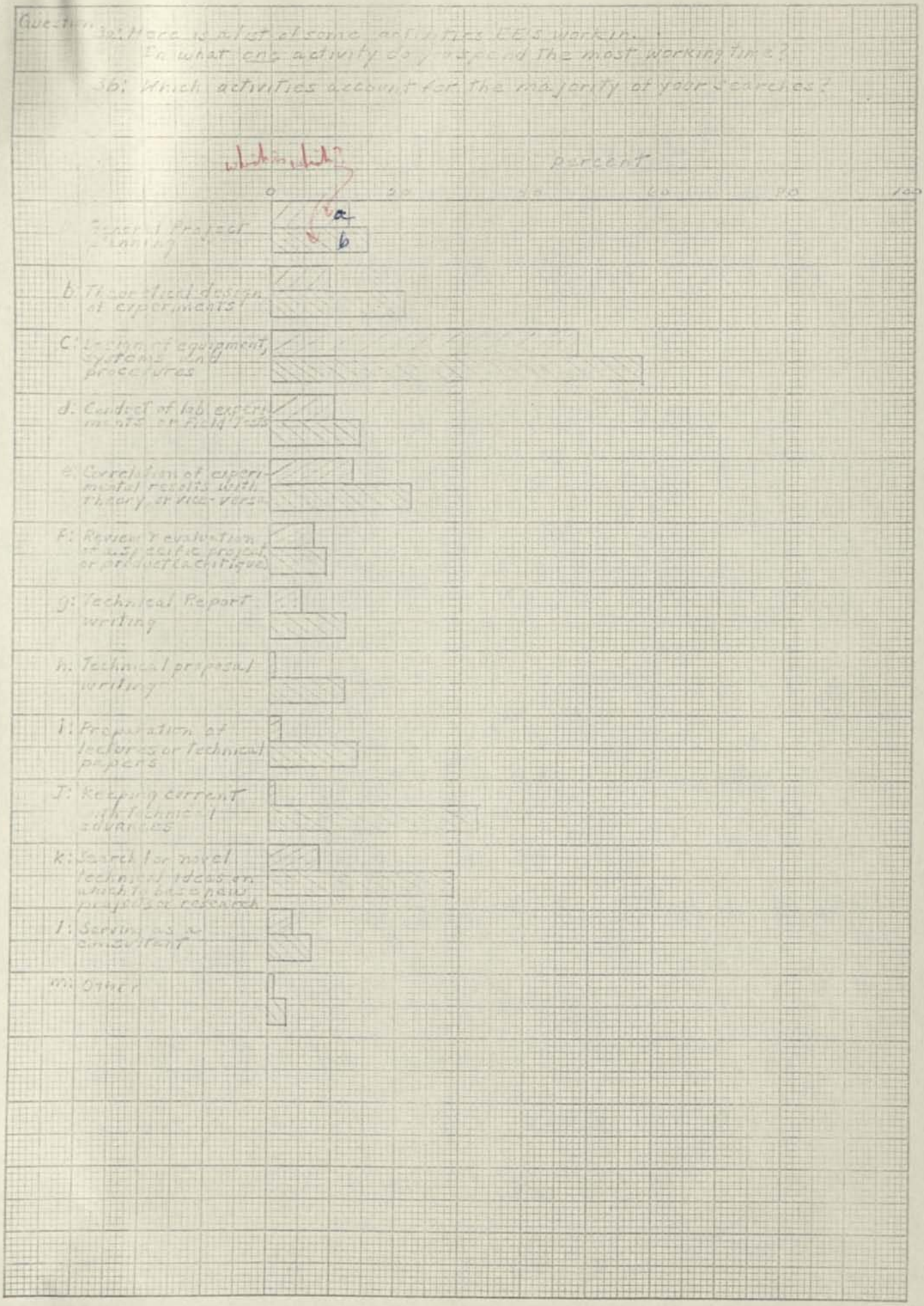
2. Roughly, how many?

Number of Searches	Percent
1–2	
3–5	
6–10	
11 or More	
Specific No. Not Given	

How many did not conduct research? only 2

Question 35: Here is a list of some activities LES work in. In what one activity do you spend the most working time?

Question 36: Which activities account for the majority of your searches?



Question 3C: Now I'd like to ask you about the most recent stretch you did or had someone else do while engaged in one of the activities you named. Which of these activities you named required this research?

About the same as 3B

Percent

0 20 40 60 80 100

a: General project planning

b: Theoretical design of experiments

c: Design of equipment, systems and procedures

d: Conduct of lab experiments or field tests

e: Correlation of experimental results with theory, or vice versa

f: Review & evaluation of a specific project or product (a critique)

g: Technical Report writing

h: Technical proposal writing

i: Preparation of lectures or technical papers

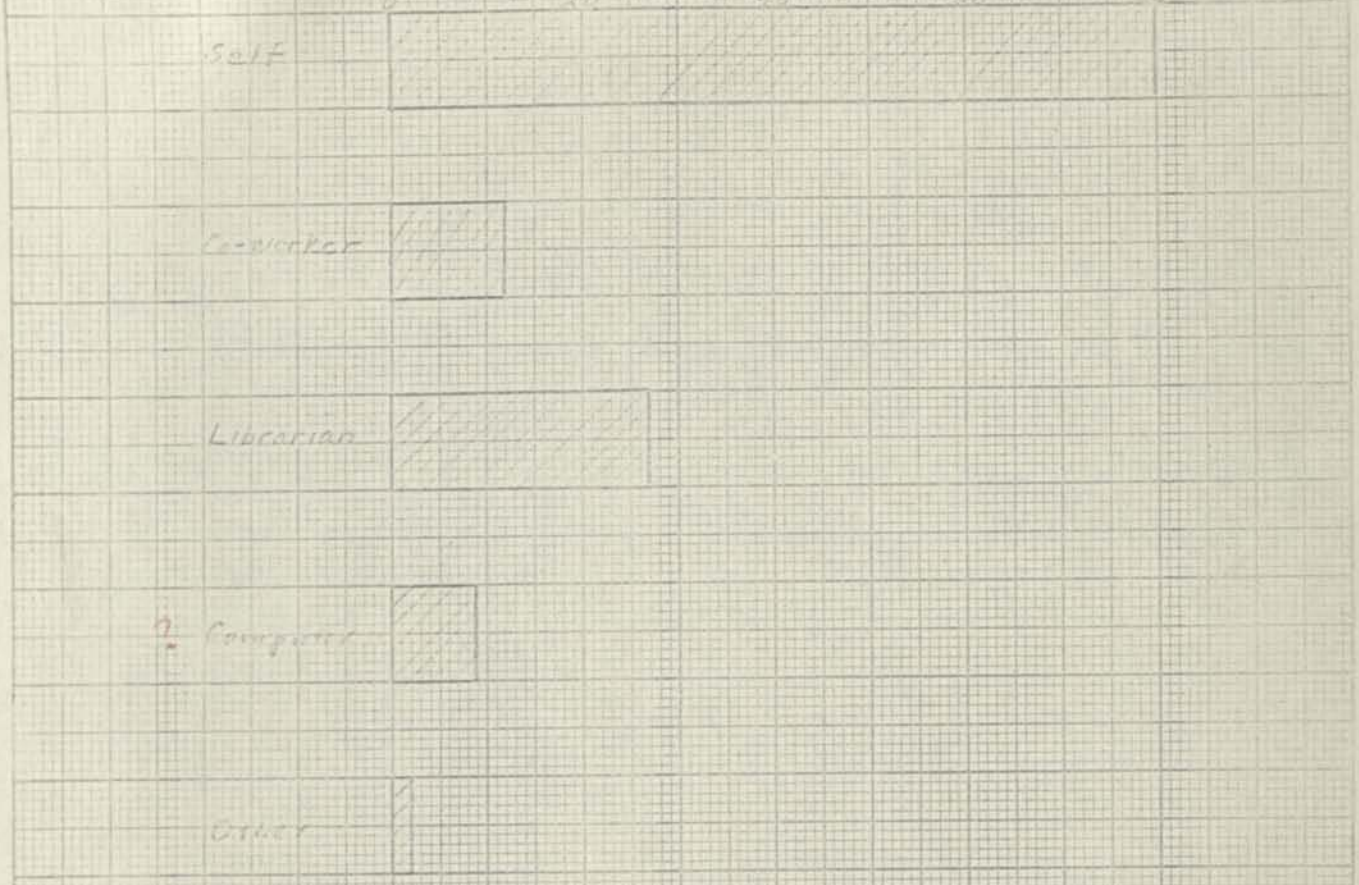
j: Keeping up to date with technical advances

k: Search for novel technical solutions which will lead to new projects or research

l: Serving as a consultant

m: Other

Question 2: Who conducted the search - you, a co-worker, a librarian, or someone else?



2.

Question 5: Through what library or other offices was the search conducted?

should have asked, "what facilities were used for this search?"

Percent

	0	20	40	60	80	100
Company Library						
Public						
University or College						
Other						

Question 9: Which of these statements most nearly describes how urgently you needed the search results when you requested the search? Ignore the importance of the results which you received later.

Percent

0 20 40 60 80 100

Very Urgent...	1%
Important...	
Not Very Important...	

Question 10: Sometimes a scientist runs up against important information and sometimes it adds little to the scientist's knowledge. Which of these statements most nearly describes how important the results were?

	Percent
Very Important	
Not Very Important	
Unimportant	

SRI ELECTRICAL ENGINEERS

Name	Date of Degree	Degree	Job Title	Organization
Aasted, J.	1956	MSEE		
Adams, M.	1948	BSEE, MSEE	Group Head	Computer Techniques
Amara, R.	1958	Ph.D. EE	Manager	General Systems
Anderson, J.R.	1940	MSEE	Manager	Computer Techniques
Andreason, M.G.	1952	MSEE	Sr. Research Engr.	Electromagnetics
Austad, R.W.	1955	BSEE	Research Engineer	Computer Techniques
Babcock, D.	1960	MSEE	Head	Radio Systems
Barnes, C.W. jr.	1936	BSEE	Sr. Research Engr.	Electron Devices
" "	1954	Ph.D. EE	"	"
Baron, M.J.	1959	MSEE	Research Engineer	Communication&Propagation
Battelle, R.B.	1950	BSEE/BA-Math	Sr. Research Engr.	Weapons Systems
Berg, M.R.	1956	MSEE	Sr. Research Engr.	Communication&Propagation
Bialik, J.J.	1950	BSEE	Research Engineer	Computer Techniques
Blanchard, H.P.	1937	MSEE	Manager	Weapons Systems
Bliss, J.C.	1961	Ph.D. EE	Research Engineer	Control Systems
Bourne, C.	1957	BSEE	Research Engineer	General Systems
Bryan, J.H.	1952	MSEE	Research Engineer	Weapons Systems
Burch, G.H.	1952	MSEE	Research Engineer	Computer Techniques
Carter, P.S.	1954	Ph.D. EE	Sr. Research Engr.	Electromagnetics
Chown, J.B.	1951	BSEE	Sr. Research Engr.	Electromagnetics
Clark, C.B.	1942	BSEE	Sr. Research Engr.	Computer Techniques
Clark, E.N.	1959	BSEE	Research Engineer	Communication&Propagation
Cline, J.	1950	Ph.D.EE	Sr. Research Engr.	Electromagnetics
Cohn, S.B.	1948	Ph.D.EE	Manager	Electromagnetics
Condon, D.	1955	BSEE	Research Engineer	Computer Techniques
Cox, B.	1948	BSEE	Sr. Research Engr.	General Systems
Crane, H.D.	1960	Ph.D.EE	Sr. Research Engr.	Computer Techniques
Daly, R.F.	1958	MSEE	Research Engineer	Communication&Propagation
Davies, L.E.	1950	MSEE	Sr. Research Engr.	Weapons Systems
Durfey, G.L.	1953	BSEE	Research Engineer	Communication&Propagation
Dyce, R.B.	1955	Ph.D.EE	Assistant Group Head	Communication&Propagation
Elpel, E.A.	1958	MSEE	Research Engineer	Radio & Weather Sciences
Elspas, B.	1955	Ph.D.EE	Sr. Research Engr.	Computer Techniques
Engelbart, D.	1955	Ph.D.EE	Sr. Research Engr.	Computer Techniques
English, W.K.	1950	BSEE	Research Engineer	Computer Techniques
Fishman, M.	1948	Ph.D.EE	Sr. Research Engr.	Weapons Systems
Fraser, E.C.	1960	MSEE	Research Engineer	Control Systems
Forsen, G.E.	1957	MSEE	Research Engineer	Applied Physics
Frohback, H.F.	1948	BSEE	Research Engineer	Graphic Sciences
Gardiner, E.W.	1951	MSEE	Research Engineer	Control Systems
Gaver, P.H.	1948	BSEE	Sr. Operations Analyst	Weapons Systems
Geppert, DV	1948	MSEE	Research Engineer	Electron Devices
Getsinger, W.J.	1959	MSEE	Sr. Research Engr.	Electromagnetics

SRI ELECTRICAL ENGINEERS (CONTINUED -2-)

Name	Date of Degree	Degree	Job Title	Organization
Gilden, M.	1955	Ph.D.EE	Research Engineer	Electromagnetics
Gillettee, P.R.	1942	BSEE	Sr. Physicist	Weapons Systems
Goddard, E.	1947	MSEE		
Goldberg, J.	1954	MSEE	Sr. Research Engr.	Computer Techniques
Gould, R.G.	1954	MSEE	Research Engineer	Communication&Propagation
Green, M.W.	1947	BSEE	Sr. Research Engr.	Computer Techniques
Guthart, H.	1956	BSEE	Research Engineer	Electromagnetics
Hagn, G.	1959	BSEE	Research Engineer	Communication&Propagation
Heintz, R.M. jr.	1947	MAEE	Sr. Research Engr.	Control Systms
Hesterman, J.W.	1958	BSEE	Research Engineer	Computer Techniques
Honey, R.C.	1953	Ph.D.EE	Technical Program Coordinator	Electromagnetics
Hughes-Caley, G.F.	1922	BSEE	Head, Mech. Group	Control Systems
Jaye, W.E.	1952	MSEE	Research Engineer	Communication&Propagation
Jones, E.D.	1958	MSEE	Research Engineer	Graphic Sciencew
Jones, E.M.T.	1950	Ph.D.EE	Head, Microwave Group	Electromagnetics
Jones, J.H.=	1948	BSEE	Research Engineer	General Systems
Kamphoefner, F.J.	1949	Ph.D.EE	Manager	Control Systems
Kautz, W.H.	1951	Ph.D.EE	Sr. Research Engr.	Computer Techniques
Keenan, M.G.	1953	BSEE	Research Engineer	Electromagnetics
King, B.D.	1959	MSEE	Research Engineer	Control Systems
Leadabrand, R.	1953	MSEE	Head, Propagation	Communication&Propagation
Lincicome, D.C.	1953	BSEE	Research Engineer	Computer Techniques
Lomax, J.B.	1951	MSEE	Sr. Research Engr.	Radio & Weather Sciences
Long, R.A.	1951	BSEE	Research Engineer	Communication&Propagation
Lynch, W.M.	1946	MSEE	Sr. Research Engr.	Radio and Weather Sciences
Macovski, A.	1953	MSEE	Research Engineer	Graphic Sciences
Madvig, R.M.	1943	BSEE	Research Engineer	Control Systems
Martin, J.A.	1957	MSEE	Research Engineer	Electromagnetics
Masher, D.P.	1953	MSEE	Research Engineer	Computer Techniques
Matthaei, G.L.	1951	Ph.D.EE	Assistant Head, Microwave Group	Electromagnetics
Meisling, T.	1952	Ph.D.EE	Sr. Scientific Advisor	
Merritt, P.E.	1960	Ph.D.EE	Head, Electronics Group	Control Systems
Moore, E.J.		Ph.D.EE	Head, Systems Evaluation	Weapons Systems
Morita, T.	1949	Ph.D.EE	Head, Radiation Systems	Electromagnetics
Nee, D.	1949	BSEE	Research Engineer	General Systems
Nielson, D.L.	1956	BSEE	Research Engineer	Communication&Propagation
Nilsson, NJ	1958	BSEE		
Nitzan, D.	1959	Ph.D.EE	Research Engineer	Computer Techniques
Noe, J.D.	1948	Ph.D.EE	Director, Engr. Sciences Division	General Manager

SRI ELECTRICAL ENGINEERS (CONTINUED -3-)

Name	Date of Degree	Degree	Job Title	Organization
Olson, H.D.	1954	MSEE	Research Engineer	Communication&propagation
Orsak, L.	1959	MSEE	Research Engineer	Communication&Propagation
Parks, G.S. jr.	1958	BSEE	Research Engineer	Communication&Propagation
Peterson, A.M.	1952	Ph.D.EE	Manager, Communication and Propagation	Communication&Propagation
Pollack, M.	1958	MSEE	Research Engineer	General Systems
Post, E.A.	1936	BSEE	Manager, Radio and Weather	Radio&Weather Sciences
Presnell, R.I.	1956	MSEE	Research Engineer	Communication&Propagation
Pressman, G.L.	1956	BSEE	Research Engineer	
Priedigkeit, J.H.	1942	BSEE	Sr. Research Engr.	Radio and Weather Sciences
Proctor, E.K. jr.	1947	BSEE	Sr. Research Engr.	Weapons Systems
Reiche, L.	1948	BSEE		
Robinson, L.A.	1956	MSEE	Research Engineer	Electromagnetics
Rorden, L.H.	1955	MSEE	Research Engineer	Communication&Propagation
Rosen, C.A.	1956	BSEE	Manager, Applied Physics Lab.	Applied Physics Lab.
Rosengreen, A.	1956	MSEE	Research Engineer	Computer Techniques
Rothman, H.S.	1954	MSEE	Research Engineer	Electromagnetics
Rudr, D.	1958	MSEE	Research Engineer	Computer Techniques
Scharfman, W.	1954	MSEE	Research Engineer	Electromagnetics
Scheuch, D.R.	1948	Ph.D.EE	Director, Elec. Radio Sciences	General Manager
Schlobohm, J.	1954	MSEE	Research Engineer	Communication&Propagation
Shapiro, E.B.	1953	MSEE	Research Engineer	General Systems
Sharp, E.D.	1956	MSEE	Research Engineer	Electromagnetics
Shepherd, R.A.	1960	BSEE	Research Engineer	Electromagnetics
Short, R.	1961	Ph.D.EE	Research Engineer	Computer Techniques
Sifford, B.	1960	MSEE	Research Engineer	Communication&Propagation
Singleton, R.	1960	BS&MAEE	Research Math Statis.	Math Sciences
Spindt, C.A.	1961	BSEE		
Steele, C.M.	1946	BSEE	Sr. Research Engineer	Control Systems
Stoltz, P.	1950	BSEE	Research Engineer	Weapons Systems
Tanner, R.L.	1953	Ph.D.EE	Manager, Electromag.	
Templeton, L.	1959	BSEE		
Vance, E.F.	1956	MSEE	Research Engineer	Electromagnetics
VanDeRiet, E.R.	1953	MSEE	Research Engineer	Computer Techniques
Vincent, W.R.	1948	MSEE	Head, Communications	Communication&Propagation
Weinstein, I.J.	1956	BSEE	Research Engineer	Weapons Systems
Wells, R.J.	1956	BSEE	Research Engineer	Weapons Systems
Whitby, O.	1949	Ph.D.EE	Staff Scientist	General Systems
Whitson, A.	1950	MSEE	Research Engineer	Communication&Propagation
Wiley, G.S.	1941	BSEE	Head, Operations Analysis	Weapons Systems
Wing,R.Y.	1948	BSEE	Sr. Executive Engr.	Engineering Sciences Div.
Winkelman, R.E.	1953	MSEE	Research Engineer	Communication&Propagation

SRI ELECTRICAL ENGINEERS (CONTINUED -4-)

Name	Date of Degree	Degree	Job Title	Organization
Wolfran, R.T.	1950	BSEE	Research Engineer	Communication&Propagation
Woodbury, J.R.	1953	BSEE	Research Engineer	Radio and Weather Sciences
Wright, L.G.	1949	BSEE	Development Engr.	Applied Physics
Yabroff, I.	1957	Ph.D.EE	Sr. Research Engr.	Weapons Systems
Yadavalli, S.	1960	Ph.D.EE	Sr. Math Physicist	Math Sciences
Young, Leo	1959	Ph.D.EE	Sr. Research Engr.	Electromagnetics
*Vassiliadis, A.	1961	Ph.D.EE	Research Engineer	Electromagnetics
Zeidler, H.	1943	MSEE	Group Head, Device and Circuit	Computer Techniques

*Belongs in the V's (sorry!)

RT

ENGINEERING PERSONNEL WITH BACHELOR DEGREE

Addis, M. L. - 1954- BA Secty
Alcorn, C. L. - 1935 - BS
Anderson, M. - 1949 - BS Math
Andrew, E. E. - 1957 - BA
Austad, R. W. - 1955 - BS EE, BA
Bailey, K. K. - 1957 - BS
Barnes, C. Jr. - 1936 - BS EE
Barta, V. P. - 1942 - BS Physcs
Battelle, R. B. - 1950 - BS/BA EE Math
Bialik, J. J. - 1950 - BS EE
Blahnik, C. E. - 1945 - BA
Bollen, R. - 1959 - BS Physcs
Bourne, C. - 1957 - BS EE
Bowers, B. - 1934 - BA Draftsman
~~Bradley, R. E. - 1956 - BS~~
Bradley, R. E. - 1952 - BS
Chown, J. B. - 1951 - BE EE
Clark, C. B. - 1942 - BS EE
Clark, E. M. - 1959 - BS EE
Clarke, E. A. - 1945 - BA Math
Clarke, L. C. - 1942 - BS
Condon, D. - 1955 - BS EE
Cox, B. - 1948 - BS EE
Cribbins, B. - 1950 - BA
Custer, R. J. - 1958 - BS
Cutler, W. C. - 1960 - BS Math
Daniel, R. D. - 1948 - BS
Deatrick, M. - 1955 - BA
Denisevich, P. - 1939 - BS
Diether, E. L. - 1954 - BA
Dodge, C. A. - 1948 - BA
Dolphin, L. - 1954- BA Physcs
Durfey, G. L. - 1953 - BS EE
Elliott, S. - 1958 - BA Secty
English, W. K. - 1950 - BS EE
Erickson, H. F. - 1950 - BS
Fair, B. C. - 1960 - BS
~~Fraser, E. C. - 1952- BS~~
Ford, D. F. - 1952 - BS Agriculture
Fredriksen, A. - 1957 - BA Physcs
Frohbach, H. F. - 1948 - BS EE
Gaver, P. H. - 1948 - BS E
Grabowski, M. - 1953 - BA
Green, M. W. - 1947 - BS EE
Guthart, H. - 1956 - B EE
Hadfield, R. G. - 1940 - BS ME
Hagn, G. - 1959 - BS EE
Harris, D B. - 1922 - BA Physcs
Hayes, B. - 1959 - BA
Hippler, M. - 1959 - BA Secty
Hirsch, M. F. - 1949 - BS Chem
Hodges, J. C. - 1959 - BS
Hori, T. - 1940- BS ME
Hubbard, J. R. - 1959 - BS
Hughes-Caley, G. F. - 1922 - BS EE
Jefferson, J. G. - 1956 - BA Math
Jennings, J. R 1940 BS-Chem, Math
Johnson, G. L. - 1952 - BA Physcs
Jenkins, S. C. - 1960 - BA Res Asst
Jones, J. H. - 1948 - BS EE
Keenan, M. G. - 1953 - BS EE
Kimbark, J. J. - 1941 - BS
Klein, R. D. - 1960 - BS
Knight, D. P. - 1951 - BA
Korb, M. - 1939 - AB

Korpi, K. W. - 1948 - BS
Kovacevich, M. A. - 1960 - BA Math
Lane, L. O., Jr. - 1947 - BS
Lantz, E. A. - 1951 - AB
Leving, L. - 1949- BA Math
Lincicome, D. C. - 1953 - BS EE
Long, R. A. - 1950 - BS EE
~~Lundberg, B. - 1955 - BS~~
MacCurdy, W. - 1934 - BS ME
MacLeod, J. A. - 1951 - BS
Madvig, R. M. - 1943 - BS EE
Mandelbaum, A. J. - 1930 - BS
McCully, L. D. - 1958 - AB Math
McGuigan, W. D. - 1942 - BS
Miller, S. W. - 1949 - BS Phys. Sci
Nice, E. V. - 1949 - BS
Nielson, D. L. - 1956 - BS EE
Noon, A. W. - 1941 - BS ME
Norton, J. C. - 1953 - BA
Omlor, P. H. - 1952 - BS
O'Neill, P. - 1951 - BA Secty
Pallas, B. J. - 1939 - AB Secty
Parent, L. E. - 1954 - ThB
Parks, G. S., Jr. - 1958 - BS EE
Penick, J. J. - 1959 - BA Math
Pickett, C. S. - 1958 - BS
Post, E. A. - 1936 - BS EE
Pressman, G. L. - 1956 - BS EE
Priedigkeit, J. H. - 1942 - BS EE
Rach, R. A. - 1950 - BA Astronomy

Radwell, G. M. - 1944 - BS Secty
Reamer, N. R. - 1932 - BA
Reche, L 1948 - BEE
Sang, H. - 1929 - BS ME
Schmidt, D. E. - 1959 - BS
Selby, A. - 1951 - BS Physics
Serebreny, S. M. - 1938 - BS Aero
Shepherd, R. A. - 1960- BS EE
Smith, F. - 1935 - BA
Sonkin, R. - 1958- BA
Spindt, CA 1961 BSEE
Spitzer, E. E. - 1950 - BS ME
Steele, C. M. - 1946 - BS EE
Stoltz, P. - 1950 - BS EE
Stone, M. - 1954 - BA Secty
Strader, R. A. - 1957 - AB Math
Swanson, R. W. - 1958- BS Stat
Taylor, B. G. - 1959 - AB
Templeton, L. - 1959 - BS EE
Vaden, I. - 1931 - BA Secty
Waithman, V. B. - 1941 - AB
Wallace, G. F. - 1960 - MA
Waters, J. H. - 1943 - BA Math
Weinstein, I. J. - 1956 - B EE
Wells, R. J. - 1956 - BS EE
White, W. B. - 1947 - BS Chem
Wildermuth, H. J. - 1955 - BA Meteorology
Wiley, G. S. - 1941 - BS EE
Williams, G. L. - 1950 - BS
Williams, R. D. - 1950 - BS Physics, Math
Wolfram, R. T. - 1950 - BS EE
Woodbury, J. R. - 1953 - BS EE

~~Woodworth, H. H. J. - 1955 - BS~~

Wright, L. G. - 1949 - BS EE

Yale, W. W. - 1922 - BS ?

Young, E. - 1955 - AB Physics

Teilhet, D. L. - 1927 - AB

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ENGINEERING PERSONNEL WITH MASTER DEGREE

Aasted, J. - 1956 - MS EE

Adams, M. - 1948 - EE BS & MS EE

Anderson, J. R. - 1940 - MS EE

Andreason, M. G. - 1952 - MS EE

Babcock, D. - 1960 - MS EE

Baer, J. A. - 1957 - MS EE

Bardens, J. A. - 1960 - MA Math

Baron, M. J. - 1954 - MS EE

Berg, M. R. - 1956 - MS EE

Blackmer, R. H., Jr. - 1955 - MS Meteorology

Blanchard, H. P. - 1937 - ~~EE~~ EE

~~Bliss, J. - 1958 - MS~~

Blum, R. - 1955 - MS Physics

Brandon, E. T. - 1949 - MS Physics

Bryan, J. H. - 1952 - MS EE

Burch, G. H. - 1952 - MS EE

Callnon, G. W. - 1952 - MA.

Casalet, J. P. - 1953 - EE

Christman, A. C. - 1948 - MS Physics

Clark, J. R. - 1960 - MA Meteorology

Cochran, J. A. - 1957 - MS

Collis, R. T. - 1952 - MA
Cone & R 1957 MS

Dahlke, H. - 1960 MS

Dairiki, S. - 1945-47 - MS Physics BSEE

Daly, R. F. - 1958 - MS EE

Davies, L. E. -1950 - MS EE

Davis, P. A. - 1952 - MS Meteorology

Eige, J. J. - 1955 - MS ME

Endlich, R. - 1949 - SM Meteorology

Elpel, E. A. - 1958 - MS EE

Feinstein, L. - 1950 - MS ME

Fogle, B. T. - 1958 - MS Physics

Forsen, G. E. - 1957 - MS EE

Fraser, E. C. - 1960 - MS EE

Furukawa, P. M. - 1960 - MA Meteorology

Gair, F. C. - 1954 - MS Math

Gardiner, K. W. - 1951 - MS EE

Geppert, D. V. - 1948 - MS EE

Getsinger, W. J. - 1959 - MS EE

Goddard E 1947 MS EE

Goldberg, J. - 1954 - MS EE

Gould, R. C. - 1954 - MS EE

Graf, S. F. - 1950 - MS ME

Greenberg, B. - 1954 - MA Acctg

~~Guggi, W. B. - 1955 - MS~~

~~Haynes, J. L. - 1958 - MS~~

Haynes, M. E. - 1960 - BA Math

Heintz, R. M., Jr. - 1947 - MA EE

~~Heinzman, F. C. 1954 MSEE~~

Herndon, J. R. - 1955 - MA Math

Hesterman, J. W. - 1958 - MS Physics BSEE

Hossom, S. - 1959 - MA

Jaye, W. E. - 1952 - MS EE

Jones, E. D. - 1958 - MS EE

Johnson, J. J. - 1960 - MS

Kamradt, R. L. - 1957 - MS Math

Keirstead, R. - 1950 - MA Math

King, B. D. - 1959 - MS EE

Kovalik, J. T. - 1953 - MA

Leadabrand, R. - 1953 - MS EE

Lindgren, H. A. - 1951 - MS Physics

Lomax, J. B. - 1951 - MS EE

Lundberg, RE 1957 - MSME

Lynch, W. M. - 1946 - MS EE

Macovski, A. - 1953 - MEE

MacKinnon, R. R. - 1952 - MA

Martin, J. A. - 1957 - MS EE

Masher, D.P. - 1953 - MS Comm. + Elec. EE

McCarty, R. C. - 1957 - MS Math

McKenzie, A. L. - 1951 - MM

Meier, R. B. - 1952 - MA

~~Merritt, P. E. - 1953 - MS~~

Nagle, R. E. - ~~1959~~ 1961 - MS Meteorology

Nee - D. - 1949 - MA BSEE

Nelson, R. A. - 1952 - MS

Newgard, P. M. - 1958 - MS ME

Olson, H. D. - 1954 - MS EE

Orsak, L. - 1959 - MS EE

Parks, J. M. - 1958 - MS Math

Pease, M. C. - 1948 - MA Chem

Peters, D. W. - 1960 - MS Engrg Science

Philp, S. - 1954 - MA Math

Pollack, M. - 1958 - MSEE

Presnell, R. I. - 1956 - MSEE

Proctor, E. K., Jr. - 1947 - MS BSEE

Robinson, L. A. - 1956 - MSEE

Rorden, L. H. - 1955 - MS EE

Rosengreen, Arne - 1956 - MS EE

Rothman, H. S. - 1954 - MEE

Ruder, D. - 1958 - MS EE

Scharfman, W. - 1954 - MSEE

Schlobohm, J. - 1954 - MS EE

Shapiro, E. B. - 1953 - MS EE

Sharp, E. D. - 1956 - MS EE

~~Short, R. - 1956 - MS~~

Sifford, B. - 1960 - MS EE

Singhous, H. E. - 1951 - MS Physics

~~Smith, K. D. - 1958 - MS~~

~~Smith, K. F. - 1958 - MS~~

Spencer, J. L., Jr. - 1956 - MA

Staffanson, F. - 1952- MS

Stevens, J. C. - 1951 - MA

~~Swallow, K. P. - 1952 - MA~~

Taylor, W. C. - 1956 - MS

Todd, R. - 1960 - MS

Tomlin, F. K. - 1958 - MS Math

Twery, R. J. - 1952 - MA Math

Vance, E. F. - 1956 - MS EE

VanDeRiet, E. K. - 1953 - MS EE

Viezee, W. - 1959 - MA Vassiliades

Vincent, W. R. - 1948 - MS EE

Wallace, C. 1960 - MA Math

Weitbrecht, R. H. - 1952- MS Astronomy

Whitson, A. - 1950 - MS EE

Wiebenson, W. E. - 1950 - MA Math

Wiegman, E. J. - 1952-MA Math

Wing, R. Y. - 1948 - MBA BSEE

Winkelman, R. E. - 1953 - MS EE

Woodworth, H. - 1961 - MSME

Younker, L. - 1942 - MA Physics

Zeidler, H. - 1943 - MS EE

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ENGINEERING PERSONNEL WITH PhD DEGREE

Ablow, C. M. - 1951 Math
Alverson, R. C. - 1957 Math
Amara, R. C. - 1958 EE
Barnes, C. W., Jr. - 1954 EE
Bennion, D. R. - 1956 EE
Bliss, J. C. - 1961 EE
Brain, A. E. - 1951 Physics
Brandstatter, J. - 1950 Physics, Math
Brock, P. - 1951 Math
Brown, A. S. - 1958
Carter, P. S. - 1954 EE
Cline, J. - 1950 EE
Cohn, S. B. - 1948 EE
~~Cordes, H. O. - 1952~~
Crane, H. D. - 1960 EE
~~Crane, S. G. - 1949~~
Crews, R. W. - 1952 Physics
Cristal - E.C. - 1961
Dennis, A. S. - 1955
Dyce, R. B. - 1955 EE
Eldredge, K. R. - 1950
Elspas, B. - 1955 EE
Engelbart, D. - 1955 EE
Eshleman, V. R. - 1952
Evans, G. W. - 1951 Math
Freud, A. W. - 1956

Fishman, M. - 1948 EE
Flammer, C. C. - 1949
~~Gabriel, W. F. - 1950~~
Gilden, M. - 1955 EE
Gillette, P. R. - 1942 BSEE
Hansen, W. W. - 1941 Physics
Harris, F. B., Jr. - 1955 Physics
Hermes, R. M. - 1950
Holl, M. M. - 1955 Meteorology
Honey, R. C. - 1953 EE
Janusz, T. P. - 1959 Physics
Jones, E. M. T. - 1950 EE
Kamphoefner, F. J. - 1949 EE
Kautz, W. H. - 1951 EE
Larson, H. J. - 1960
Ligda, M. G. H. - 1953 Meteorology
Lucke, W. S. - 1949 Physics
Madow, W. - 1938 Math
Matthaei, G. L. - 1951 EE
Meeland, T. - 1952
Meisling, T. - 1952 EE
Merritt, P. E. - 1960 EE
Minnick, R. C. - 1953 App Math
Moore, E. J. EE

Morita, T. - 1949 EE
Nanevicz, J. E. - 1958 EE
Nelson, R. A. - 1961 Physics
Nilsson, N. J. - 1958 BSEE
Nitzan, D. - 1959 EE
Noe, J. D. - 1948 EE
Novikoff, A. B. J. - 1949 Math
Perry, C. L. - 1949
Peterson, A. M. - 1952 EE
Pettyjohn, W. J. - 1952
Pierce, E. T. - 1950 Maths + Physics
Reynolds, D. K. - 1948
Rice, P. - 1943 Physics
Rosen, C. A. - 1956 BEE EE + Physics
Scheuch, D. R. - 1948 EE
Short, R. - 1961 EE
Singleton, R. - 1960 BSEE, MSEE
Stone, J. J. - 1961 Math
Tanner, R. L. - 1953 EE
Tobey, A. R. - 1948 Physics
Weaver, D. K., Jr. - 1959
Whitby, C. - 1949 Comm Eng'g
Yabroff, I. - 1957 EE
Yadavalli, S. - 1960 Physics + EE
Young, Leo - 1959 EE
~~Stone, J. - 1961~~
Vassiliadis, A. - 1961 EE

~~11~~ 13

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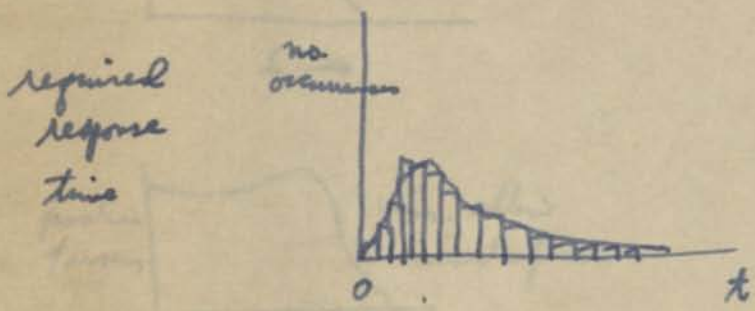
6-23-61 mrs

Develop List of Requirements
Measure Requirement

Rank Requirements - for each of several types of activities (not activities as defined by individuals)

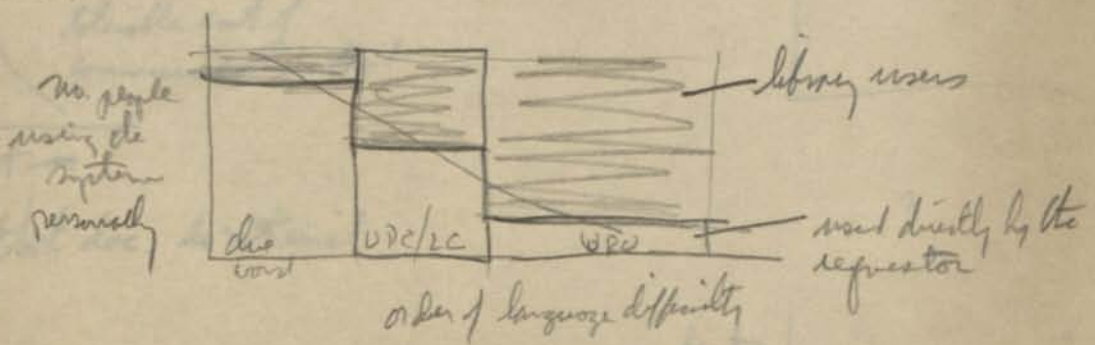
1. Give a group of 40 requirements to a pilot group, & ask them to rank them by importance

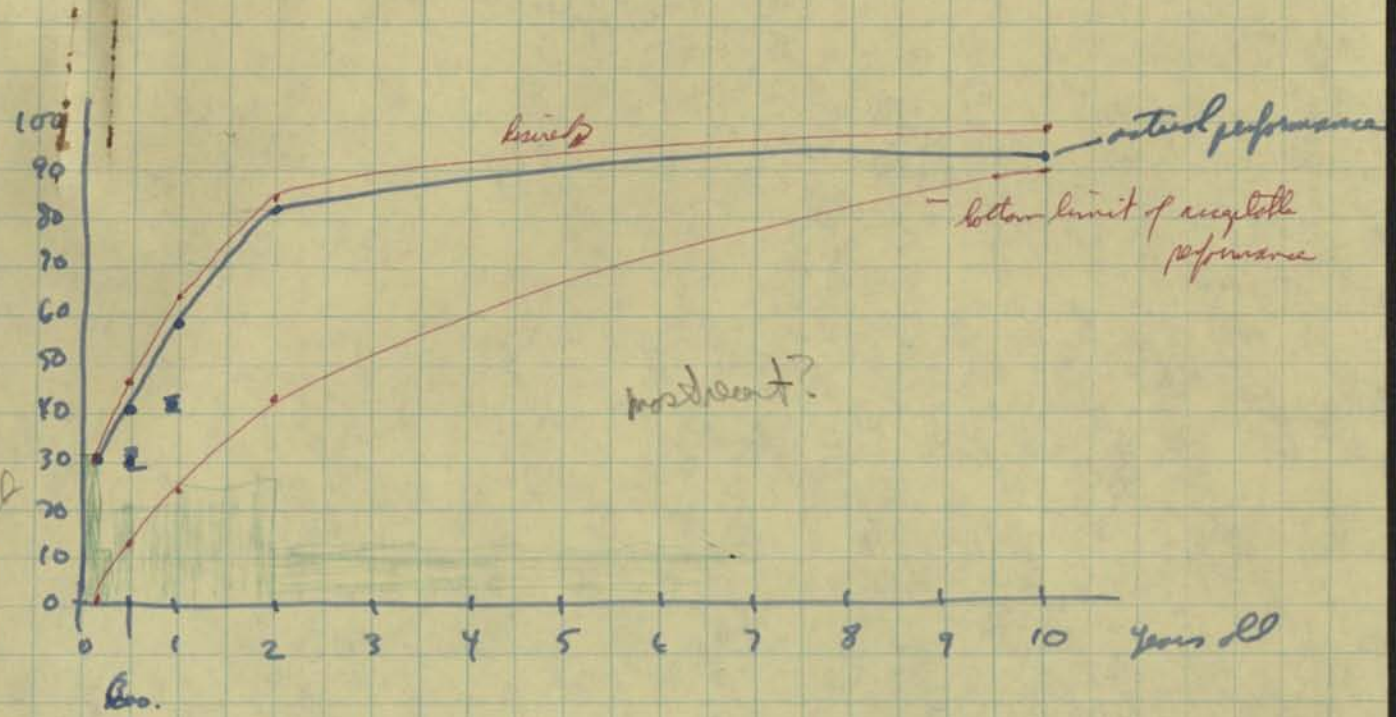


2. monitor the library requests & ask each requester what amount of delay would be intolerable.

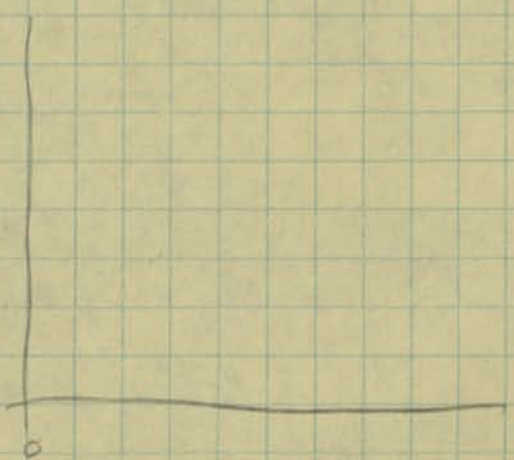
Ease of Communication

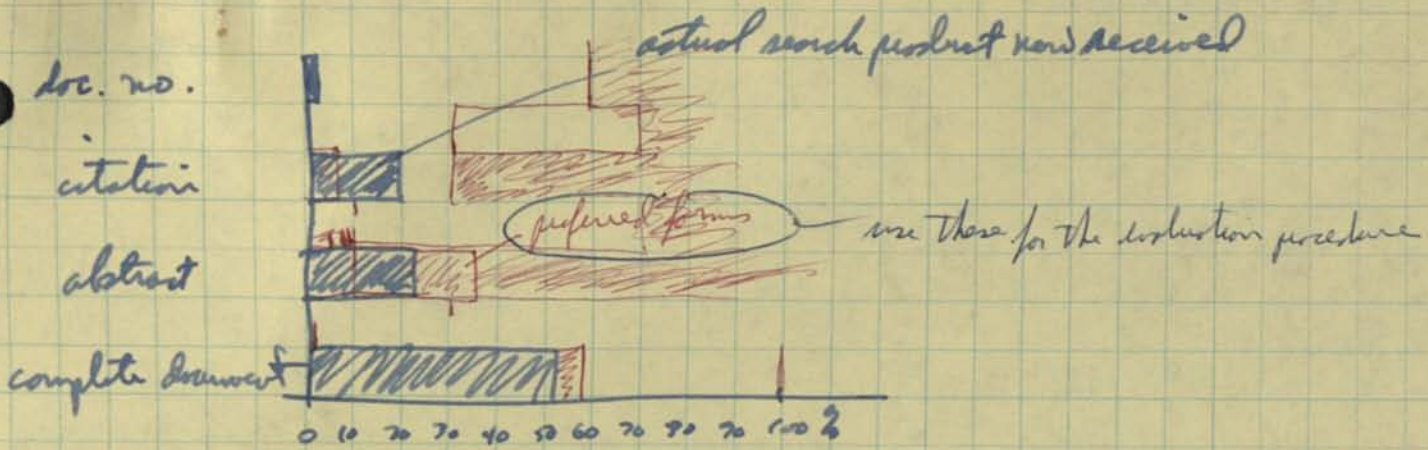
1. Get reactions, comments from users who are exposed to varying degrees of system language complexity (e.g. change word to WRU) - Try to find a point where the language becomes so complex that the users don't bother to learn it.

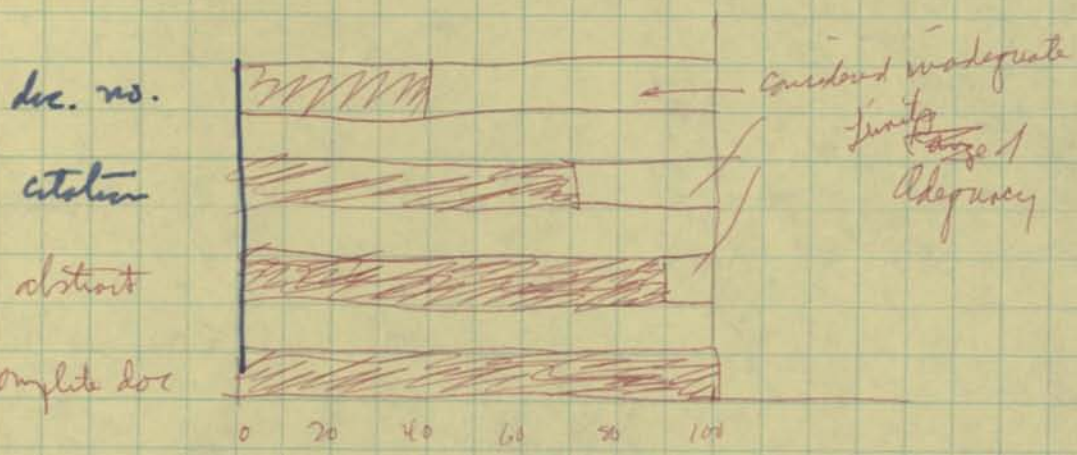




12. Age of Search Results







13. Preferred Type of Search Product

15. Rankings

Assume

- Rank weighting × no. occurrences gives an indication of a semantic task

a. min. delay
15
1.5
14.
24.
36.
(2) 5.
12.
7.
114.5

b. min. inval.
1
12
28
(6) 35
96
63
235

c. min. rel. calculated
13
24
30
(1) 16
25
108.

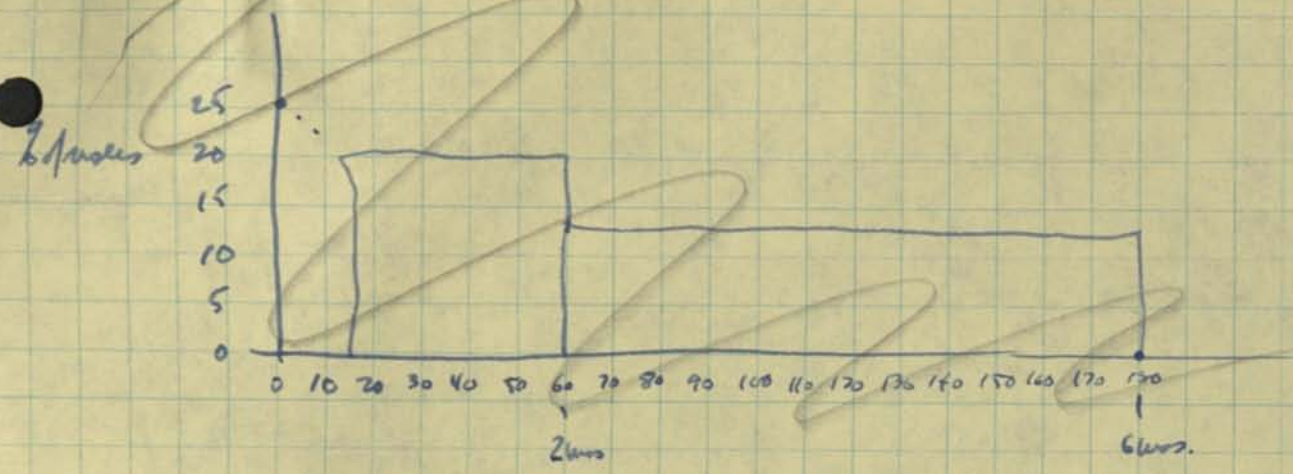
d. form of product
5
18
9
32
(3) 50
18
6.5
35
1735

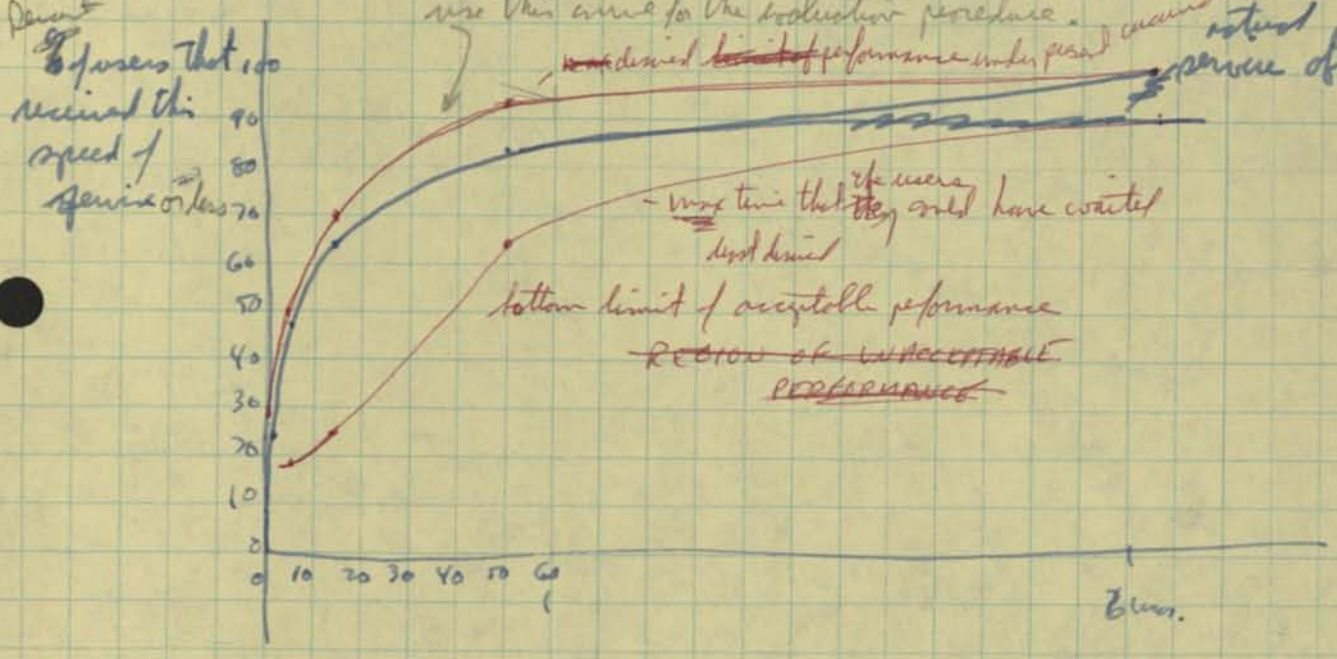
e. command/node etc.
3
16
2.5
21
(5) 20
35
36
6.5
42
182.0

f. loss of communication
2
1.5
4
3
(7) 20.
25.
66.
119
240.5

g. reliability/reach
4
8
2.5
27.
(4) 32
40
30
35
178.5

6 mos = 180 days

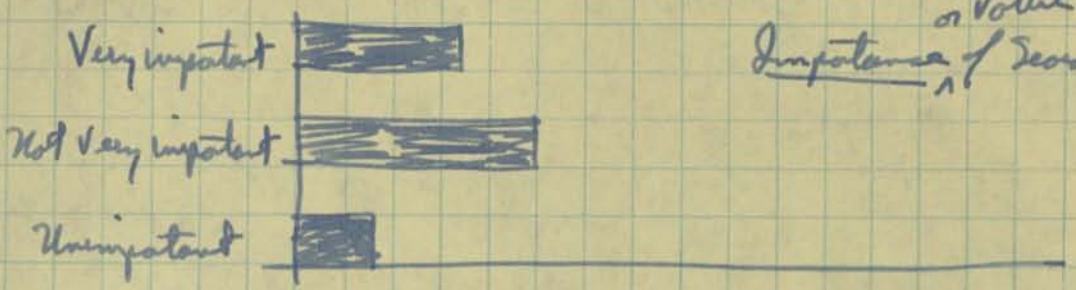




11. Response Delay

Initial Need for Search Result

Importance or Value of Search Results obtained



9/10 Urgency & Value of Results

An Approach to Promoting the Applications of Statistical Techniques by the Industrial Engineer[1]

by RICHARD A. DUDEK[2]

Research Associate in Management Engineering, Schools of the Health Professions, and Associate Professor, Department of Industrial Engineering, University of Pittsburgh

INCREASING interest in statistical techniques for the field of Industrial Engineering is apparent from the many articles concerning these techniques which are appearing in current Industrial Engineering literature. It is probable that increased use of the tools of statistics would promote greater precision in the analysis of many problems which the Industrial Engineer encounters. There seems to be little doubt that the Industrial Engineering profession must endeavor to promote the use of statistical tools as extensively and rapidly as possible. This article will attempt to point out one approach by which adaptation of these tools may be achieved more quickly.

HIGHER MATHEMATICS

The techniques of higher mathematics have been used as tools to obtain more precise and quantitative methods in many situations. During the "maturing process," other professions went through transition periods similar to that which appears to face Industrial Engineering. It would be well to note how these professions coped with the situation of quantifying their approach to problems. As the biologists, psychologists, agriculturists, economists, and others required more precise quantitative methods of analysis, they borrowed from the disciplines of statistics and advanced mathematics. In many instances these professions adapted the techniques to their specific needs, and in the process, contributed to the advancement of the discipline from which they borrowed. As an example one might cite R. A. Fisher's factorial design of experimentation in agricultural research. It seems that Industrial Engineers, who have a thorough background in basic mathematics, might gain by emulating these "older" professions.

There are publications within these "older" professional groups which the Industrial Engineer might find useful. This literature contains many articles discussing and explaining specific applications of mathematical methods to various kinds of problems. Of course, the usual problems are those of interest to the profession in which the publication is most widely circulated.

The Industrial Engineer would have to study these articles not only from the standpoint of the method of applying the mathematical tool, but also from the standpoint of comparing the characteristics of the problems attacked with the problems he is encountering. He would have to translate the variables and problems discussed into Industrial Engineering variables and problems which have analogous characteristics. That is, it would be necessary for the Industrial Engineer to make a transition from the psychological, economic, or other problem discussed to a problem of cost reduction, plant layout, machine choice, etc. Once the transition was made, though, several new ideas for methods of approaching problems in management and Industrial Engineering with precise analytical tools might become apparent.

STATISTICAL PROCEDURES

Many authors of articles in these publications explain statistical procedures in nonmathematical language. This point is made by Mosteller (3) in the opening paragraph of the Statistical Theory and Research Design section of the 1953 *Annual Review of Psychology*. He states:

> During 1951 and 1952 there has been a continuation of the trend to present in nonmathematical language statistical material not so long ago available only to readers willing and able to cope with strong doses of mathematics. These expository articles state the assumptions underlying the statistical models they discuss, and sometimes offer alternative procedures with differing assumptions for solving the same problem. Some articles present examples worked in detail so readers are supplied with a program for computation.

This work provides a summary of much of the work done in 1951 and 1952 along the lines expressed in the

[1] A portion of the material for this article was obtained by the author while working for the degree of Doctor of Philosophy, in the Department of Industrial and Management Engineering in the Graduate College of the State University of Iowa under the guidance of Professor J. Wayne Deegan (2).

[2] The author is presently Professor and Head, Department of Industrial Engineering, Texas Technological College, Lubbock, Texas.

above quotation. That many areas of statistical procedures are covered is indicated by the sub-topics of this section, which are: Test Methods, Selection Procedures, Nonparametric Statistics, Ranking Methods, Contingency Tables, Regression, Quick Methods, Effects on Some Common Statistics of Departures from Assumptions, Suggestions for Models or Transformations, Surveys, and Scaling. It seems apparent that the Industrial Engineer might find publications such as this of considerable aid, especially in statistical methods, in approaching many of his problems.

In giving consideration to publications of other disciplines, mention should be made of the writings with respect to mathematical procedures in the technical journals[3] of the mathematics profession. Of course, in these publications, the case study approach or explanation of the application of mathematical methods to problems of Industrial Engineering and management are minimal. The general approach is of a technical nature in the explanation of the theory of new mathematical procedures. These publications, therefore, would have the greatest meaning and be of the most help only to those individuals who have a good foundation in theoretical statistics and mathematics. The individual will have to make the transition from theory to practical application himself, and for those Industrial Engineers who could perform this function these publications would be of considerable value.

An article titled "The Constant-Sum Method Applied to Scaling Subjective Dimensions" (1) appeared in *The American Journal of Psychology*. This article will be used to illustrate how methods of other disciplines might be applied by the Industrial Engineer.

The summary of the article was:

The constant-sum method was employed to obtain scales for subjective dimensions represented by "roughness" of sandpapers and "preference" for neckties. With respect to roughness it was found that Os (observers) agreed with themselves and with each other at least on the rank-order of stimuli, and a number of specific relationships within the sets of scale-values were common to all Os. For the preference-dimensions, there was a fair degree of agreement between scales determined for different groups and between scales determined for the same group on two occasions. There were, however, sex-differences with respect to the placement of items on this dimension. It was concluded that consistencies in scale-values indicated measurement on scales that reflected more than merely the ordinal characteristics of items, although the requirements of a true ratio-scale may not have been met fully. The implications of these results were discussed and various problems arising in attempting to determine the characteristics of scales determined for subjective dimensions were considered.

[3] These include such publications as: *The Journal of the American Statistician, The Annuals of Mathematical Statistics, The Royal Statistical Society Journal, Mathematics Magazine, Applied Statistics, The American Mathematical Monthly, The American Statistical Association Journal,* and *The Journal of Mathematics and Physics.*

PRODUCTION SCALES

To make a transition of this discussion to a problem in Industrial Engineering, one must visualize in what way "scales for subjective dimensions represented by 'roughness' of sandpapers and 'preference' for neckties" suggest areas of application. Consider first the term "subjective dimensions." Many Industrial Engineering predictions are based on estimates or trends, for example, predicted production figures used in production control. Usually these figures are based on expected sales and/or historical data as they are assumed to predict consumer demands. Measures such as predicted production figures are analogous to "subjective dimensions" for the psychologist. Next, consider the term "scales for." It would be very helpful for the Industrial Engineer to have a measuring "scale" for his predictions, such as predicted production figures or expected sales which would permit more objectivity in the production control techniques. Just as the psychologist is interested in "scales for subjective dimensions," the Industrial Engineer is interested in scales for predicted production figures. Last, consider the phrase "represented by—'preference' for neckties" or any other product. Predicted production figures or expected sales reflect to a great degree the "preference" of the consumer for the various products manufactured by the plant.

Thus it follows, if "subjective dimensions" can be measured it would be well for the Industrial Engineer to base predictions on this type of "measuring scale."

Now that the transition of terms has been given consideration and some applications seem apparent, it would be well to consider the technique in detail. For purposes here, consideration will be given only the " 'preference' for neckties" experiment as follows: (1)

Method. The Os were volunteers from undergraduate psychology courses. To investigate possible sex-differences in preference, and to have some Os give ratings on two occasions, three independently constituted groups were employed: Group A, 29 men who rated the stimuli only once; Group B, 19 men who judged the stimuli in two sessions a month apart, hereafter designated as B_1 and B_2; and Group C, 29 women who judged the material only once.

The stimulus-objects judged were eight equal-sized, printed, color-productions of neckties. To control color as a variable, the samples were predominantly blue. There were 28 possible pairings of the 8 ties, and the order of presentation for judging was random except for the restriction that no tie appeared in successive pairs. Each pair was shown on a large screen by means of an opaque projector. The Os were instructed to divide 100 points between the members of each pair so as to indicate their relative degree of "liking" for the two ties. These judgments were made following a series of 20 judgments of line-lengths, which provided some experiences in making judgments in terms of point-divisions.

Results. Procedures used to compute scale values were the same as in Experiment I. Scale-values of the neckties as determined for the various groups are shown in Fig. 2.

It is apparent from Fig. 2 that the two groups of men agree quite closely with respect to the order of stimuli. One index of this agreement is *tau*, a coefficient of agreement based on the number of interchanges necessary to make two sets of orders

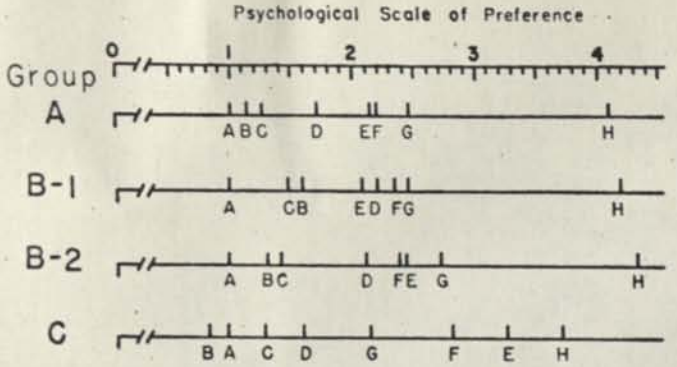


FIG. 2. Scale-Values of Eight Neckties as Determined for Three Groups of Judges.

correspond. With two interchanges the order of items for Group A corresponds to the order for Group B_1 ($\tau = 0.86$) and only one interchange results in orders identical for Group A with those from Group B_2 ($\tau = 0.93$). Three interchanges are required to make orders for Group B_1 and B_2 comparable ($\tau = 0.79$). Thus it appears that two independent groups of judges agree as well as do two judgments made by the same group on separate occasions. A mere count of interchanges does not reflect certain important uniformities manifested in the sets of scale-values for the groups of men.

Analogous with the roughness judgments, rather striking consistencies with respect to the relative distances maintained between stimulus-objects are evident from group to group.

In general, the agreement between orders for women and men is somewhat poorer. The 4, 6, and 3 interchanges required to bring about corresponding orders yield τs of 0.71, 0.57, and 0.79, respectively. Although all coefficients are significant, sex-differences with respect to preference for the neckties are suggested.

Although this technique is still in an exploratory phase, as indicated in the summary of the article, it does present an approach to the solution of a problem which would seem to have relevance in production planning. It would provide a method for obtaining certain kinds of information which would be of practical value. Even though the psychologist views the technique of using these subjective measures as a "methodological issue" since ". . . the requirements of a true ratio-scale may not have been met fully" (1), the Industrial Engineer could transform this technique into a useful method for solving some of the immediate problems with which he is faced. For example, the technique might be applied in production control, to make more precise or more reliable estimates of predicted production figures for various products.

Use of the "Psychological Scale of Preference" and the predicted preference of "Group A" (Figure 2 in the quoted material) will be used here to exemplify the possible application of this technique to production control. It will be assumed that the sales department or the market research department will provide the production control department with the predicted total sales for the forthcoming period, for example, 10,000 gallons of ice cream in the coming month. The production control department knows the various competing flavors of ice cream that must be produced and might schedule production of the various flavors based on past sales of each type. Consider the possibility that scale values for the preference of the competing flavors are available, obtained by the method described in the necktie experiment cited, say (from Scale A, Figure 2) flavor $A = 1.00$, $B = 1.13$, $C = 1.24$, $D = 1.70$, $E = 2.14$, $F = 2.19$, $G = 2.43$, and flavor $H = 4.10$. Now the prediction would be that output should be geared in these ratios so that the items will be produced in proportion to their expected sales. The formula:

$$P_i = \frac{S_i}{\sum_{i=1}^{n} S_i} \times TS$$

Where:

P_i = The production output of item i.

S_i = The scale value of item i.

$i = 1, 2, 3, \cdots, n$ or in the case cited $A, B, C \cdots, H$.

TS = Total sales

can be used to convert predicted total sales into production output figures for each of the various items. In this case, the production of flavor A would be 630 gallons, flavor $B = 710$, $C = 780$, $D = 1{,}070$, $E = 1{,}314$, $F = 1{,}370$, $G = 1{,}520$, and production of flavor H would be 2,580 gallons. Thus, knowing total sales, production figures for all products can be predicted provided that the sales of the items follow the measured preferences for the items. Now suppose a new product is added to the production schedule. There are no past sales upon which predicted production figures can be based, but a preference scale value for this new item can be obtained. So, with use of the foregoing formula the predicted production figure for this new product can be established.

There are obvious complications which can be encountered with this technique. These could arise if the sales and thus the production of the products are dependent on many variables or features, i.e., a group of products where price, design, color and size vary for each product and can affect preference. All of these variables would have to be considered as part of the stimuli affecting consumer buying habits. These considerations do complicate the picture but do not represent any real limitations so far as method is concerned.

There may be certain situations to which the technique described above would be directly applicable after a short test period. However, it is more likely that the application of this technique of scaling would require modification and extensive validation before the Industrial Engineer could include it in his kit of tools for production control. This example does not represent a tried and true technique for production control. The author has cited this case in an attempt to show how the terms of an

apparently unrelated discipline (in this instance psychology) can be translated into Industrial Engineering terms and therefore possibly be of help to the Industrial Engineer.

Many techniques that are described in the publications of other disciplines might be "adapted" to similar problems as they are encountered in Industrial Engineering. In the majority of the cases the technique cannot be just borrowed and applied, but it might be made to fit the Industrial Engineering problem. It may be a more reliable or better method than the one that the Industrial Engineer uses at present. Becoming familiar with techniques of other disciplines also will give the Industrial Engineer a new or different approach to the problem, and in this way possibly suggest a more refined or more valid method for attacking management problems. The Industrial Engineer may also contribute to the advancement of statistics and mathematics through the development and application of new approaches to management problems.

SUMMARY

Consideration has been given an approach to promoting the application of statistical techniques by the Industrial Engineer. This approach is that of borrowing from some of the "older" professions which have adapted the techniques and contributed to the advancement of the disciplines of statistics and mathematics, for example: agriculturists, biologists, economists, psychologists. A case was cited indicating the necessary translation of terms from the "foreign" discipline to the terms of Industrial Engineering. It seems apparent that the Industrial Engineer could make considerable use of statistical applications in other disciplines by visualizing and translating the variables and problems of these cases into Industrial Engineering terms.

REFERENCES

(1) Dudek, Frank J. and Baker, Katherine E., "The Constant-Sum Method Applied to Scaling Subjective Dimensions," *The American Journal of Psychology*, Vol. LXIX, December 1956, pp. 616-624.

(2) Dudek, Richard A., "The Application of Mathematical Techniques in the Field of Industrial Engineering," State University of Iowa, June 1956, (Unpublished doctoral dissertation).

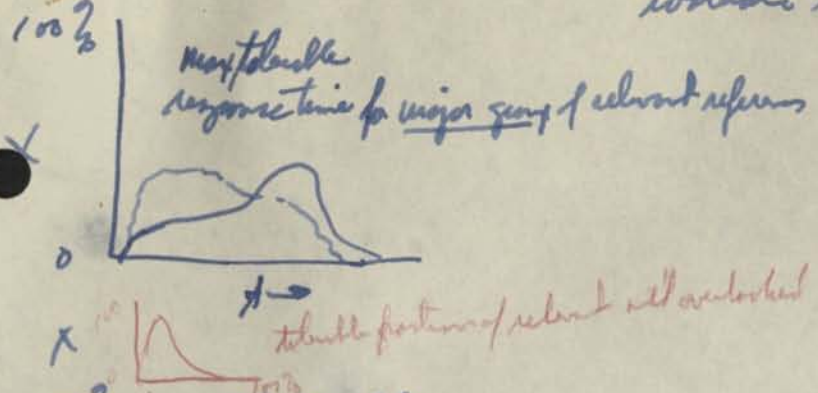
(3) Mosteller, Frederick, "Statistical Theory and Research Design," *Annual Review of Psychology*, Vol. 4, 1953, p. 407.

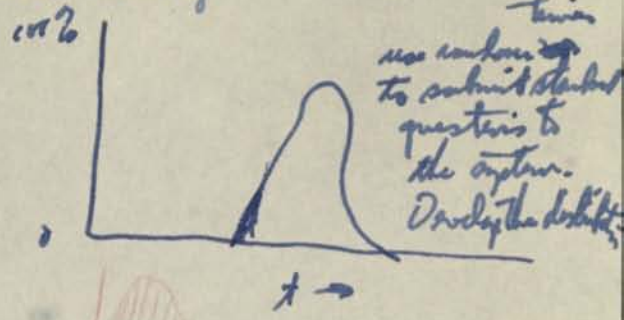
Ranking of requirements as indicated by the total group of respondents (92)

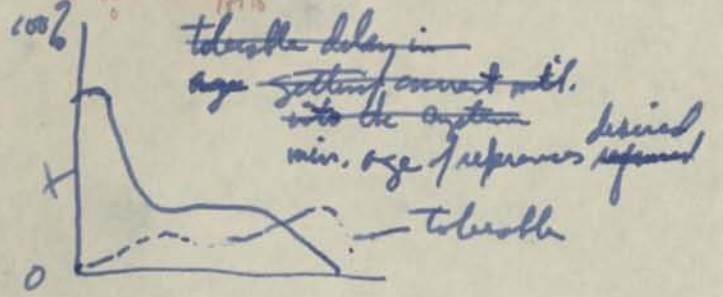
(most important)

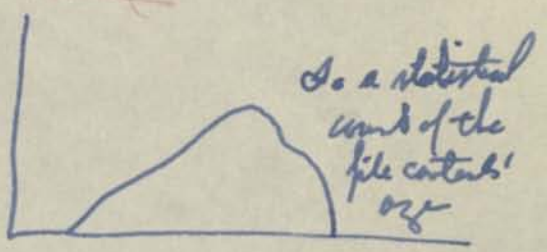
1. minimum time to get the major group of relevant references
2. " of relevant material retrieved by the search
3. certainty that specified sources over certain period of time were searched.
4. form of response (document, abstract, citation, etc.)
5. assurance that documents on a given subject do not exist
6. minimum effort to communicate search request
7. minimum irrelevant material produced by the search

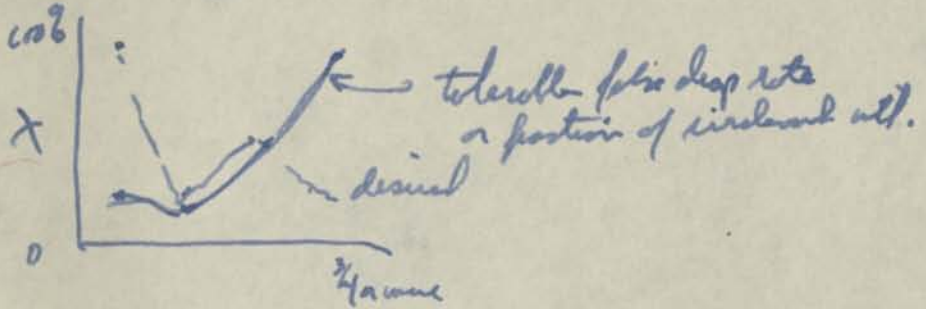
evaluate both for desired & for rejected ?
(worst case equivalent ?)

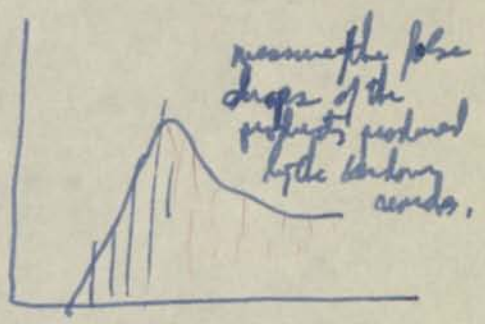


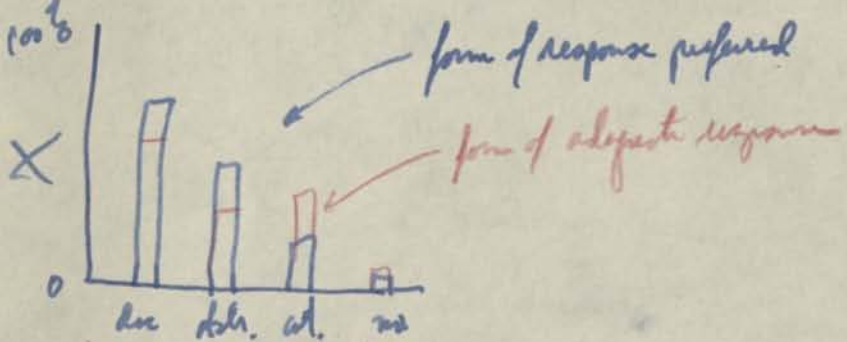


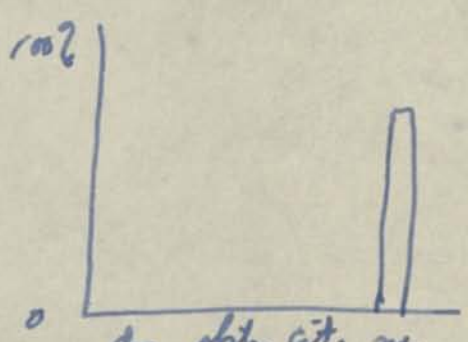


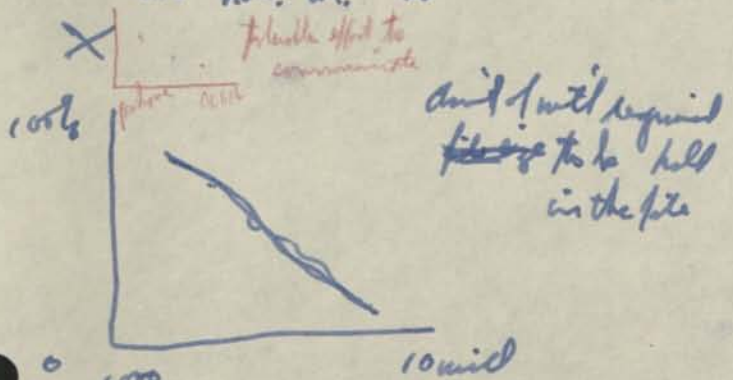


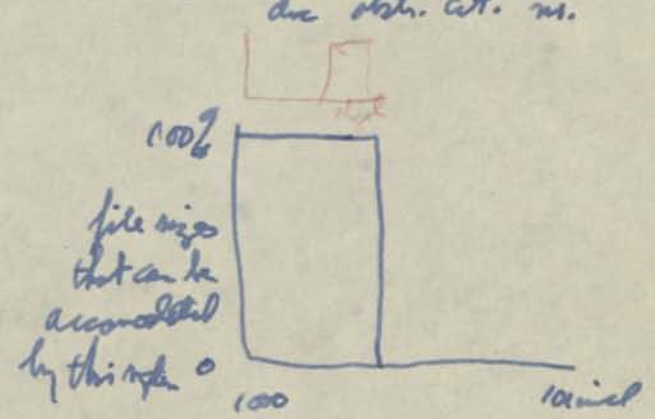












SMU

	Personal Interview Overall	PhD	MS	BS	None
I-24a When you asked for an article from a library, have you ever been supplied with a photocopy rather than the original article? Yes.	225	84	65	71	5
I-24b How do you feel, in general, about using a photocopy in place of the original?					
Rather have copy than original.	91	41	24	24	2
No Opinion	130	41	35	51	3
Doesn't like to use photocopies.	22	10	10	2	0
I-24c Is there any particular kind of photocopy you do object to using?					
Black background	33	17	9	7	0
Microfilm	41	17	11	11	2
Other	70	30	19	20	1
I-25 What percent of the time do you need this material immediately (say within two days), and what percent of the time could you wait as long as two weeks to get it without a great inconvenience?					
Two days	100	60	23	35	2
Two weeks and over	128	54	41	31	2
Evenly divided between the above	40	14	7	17	2

I-23 - The number of technical books bought personally by the overall group is:

	Number	Percent
Total	275	100
None	97	35
1-3	132	48
4-10	35	13
>10	11	4

I-24a - Of the total group 225 (82%) were given a photocopy rather than an original at least once during the last year.

I-24b - Their opinions about this practice are presented below. Some answered this question even though they had answered "no" to 24a.

How do you feel about this?	Number	Percent
Total	243	100
Rather have photocopy	91	37
No opinion	130	54
Do not like it	22	9

I-25 - What percent of the interview population would like their library requests for documents immediately (say within two days)?

	Number	Percent
Total	268	100
Two Days	100	37
Could wait two weeks	128	48
Even	40	15

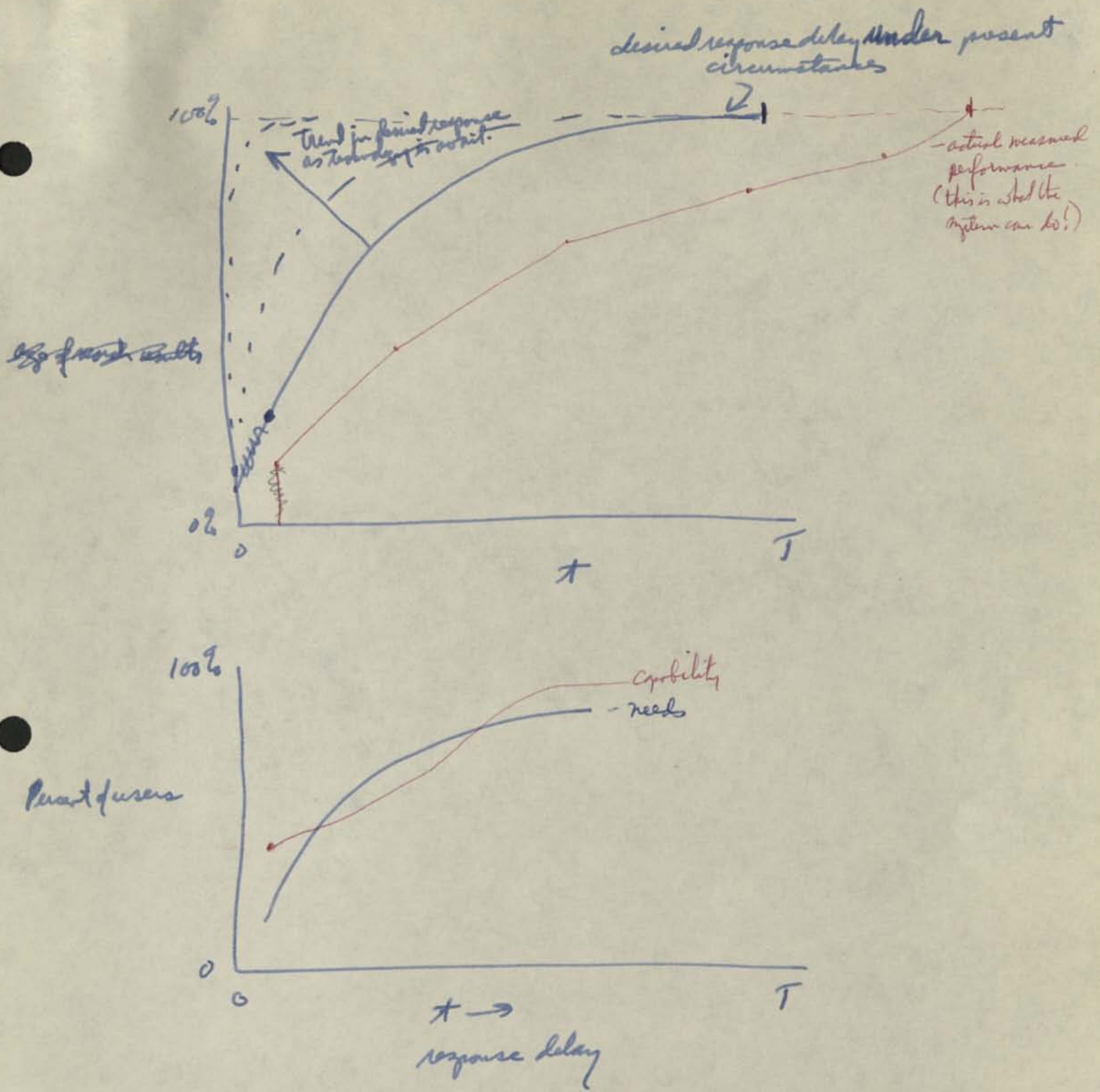
Proportioning those who indicated that they needed the requested material within two days about 50% of the time.

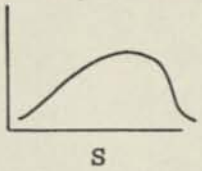
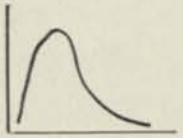
SMU

ADDITIONAL DATA FROM PERSONAL INTERVIEWS

---CURRENT INFORMATION PRACTICES---

	Personal Interview Overall	PhD	MS	BS	None
I-1a What are the sources of information in your field?					
Journals	269	108	72	83	6
Meetings	49	25	11	13	0
Personal Contacts	87	32	23	29	3
Government Reports	74	37	19	16	2
Consultants	7	3	0	3	1
Books	116		(Not Coded)		
Others	192	75	52	62	3
I-9a In your most recent literature search, how far back in time did the search go?					
1950-61	58	23	18	15	2
1930-49	78	33	22	22	1
1900-29	50	29	12	9	0
Earlier than 1900	12	9	0	3	1
I-9e Why did you do the search yourself?					
Preferred to.	64	34	17	13	0
No one else qualified to do it.	54	27	17	10	0
No one else had time to do it.	17	4	5	7	1
Other	8	2	2	2	2
I-9f Who did the search for you? (Record position and organizational connection.)					
Technical person	22	11	3	8	0
Librarian	42	16	12	14	0
Other	4	0	3	1	0
I-11a Do you generally begin a new project with a search of the literature to find out what has already been done on the subject? Yes.	199	93	50	52	4
I-11b (If NO to 11a) Do you usually do a literature search at a later point in the project? Yes.	39	9	11	17	2
I-12a Has any of your work resulted in your company conducting a patent search? Yes.	201	84	52	61	4


desired response delay under present circumstances
100%
Trend in desired response as learning occurs
actual measured performance (this is what the system can do!)
% of frequent users
0%
0
T
100%
capability
needs
Percent users
0
T
response delay

Minimum Users Requirements (Probabilistic)	Degree of Satisfaction of Requirement*		Relative Weighting Function for Importance of Requirement	Weighted Performance Number	
	System 1	System 2		System 1	System 2
Search Speed: $\Phi(S)$ 	1.0	0.6	W_1	$1.0W_1$	$0.6W_1$
Max. File Size: $\Phi(M)$ 	0.5	0.7	W_2	$0.5W_2$	$0.7W_2$
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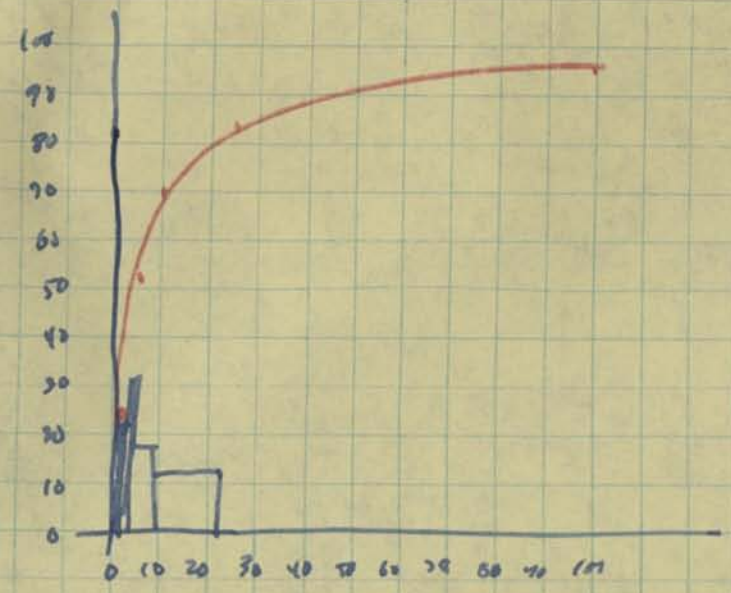
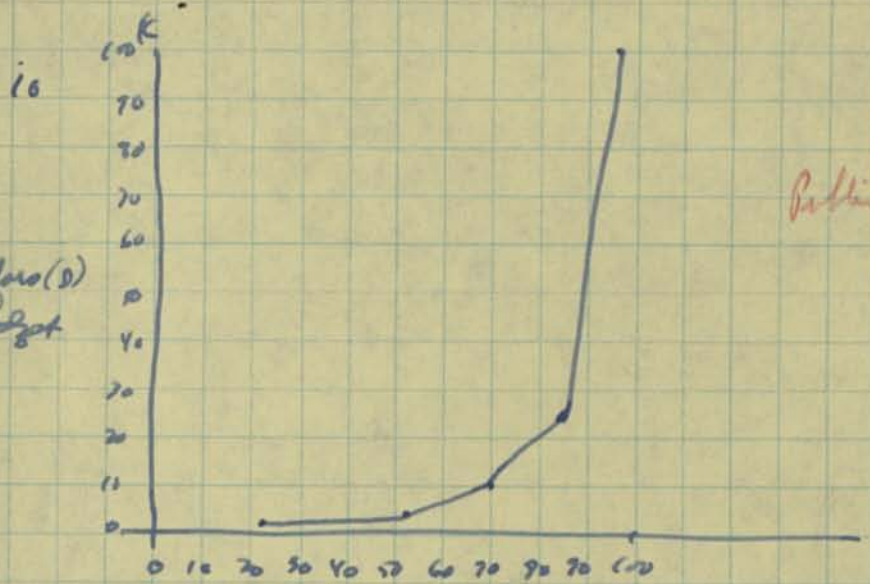
				Total	Total

*Based on comparison of the probability density functions of the requirement and the system.

TABLE I

Weighted Probabilistic Comparisons





Thous. $ dollars (D)
- total annual budget

Fraction of users with annual budget of D Dollars or less

Variety of users have widely diverse needs

How much will easier & more complete access to info benefit each of the variety of users? expected payoff? optimum amount to spend for info service?

No simple rules to choose between info systems. Evaluation techniques known to systems engineers & O.R. are hard pressed to indicate choices that satisfy all users within the time & cost constraints.

Comparison of systems is held back by insufficient knowledge of the exact requirements.

For a comparison between 2 different implementations to gain system, one needs:

a) a means (analytical or empirical) of determining performance
b) a metric (yardstick) -- compatible with the design criteria -- to describe this performance
c) design criteria that adequately reflect the system requirements. The relative value of each criterion must also be given s.t. a figure of merit may be constructed for each alternative system.

True user needs best described in probabilistic terms. ∴ Criteria may also be expressed in probabilistic terms. — derived by adequate statistical sampling of the user population.

Comparisons would be helped by standard nomenclature for the parts & procedures of the system.

When the full spectrum of requirements is compiled, great care must be taken to see that they are:

a) reasonably complete
b) self-consistent
c) weighted as to their relative worth to the user

It would be most convenient if one could put a monetary value on the attainment (in full or in part) of each requirement.

Before comparisons can be made precisely, the following steps must be traversed:

a) evolvement of complete & self-consistent requirements
b) derivation of criteria to reflect the requirements
c) calculation or measurement of system performance
d) conversion of system performance into a single metric for comparison

Suggested Approach

1. Immediate need to make choices: require rough but logical measures of worth for candidate systems.

2. long term onslaught on the problem: for better understanding of the relationship between info + scientific productivity.

Short Range Approach

1. Now restrict attention to 1 type of user.
2. delineate a system model as shown in Fig. 2 to represent of system functions
3. Define all significant Terms in a glossary
   incorporate technical + economic restraints in the model
4. establish requirements for the selected user population
   by a review of previous work in this area. & by interviews
   developed in probabilistic terms, with relative worths for each
   requirement (fully & partially satisfied)
5. Derive criteria that reflect the requirements
6. Derive standard methods of calculating system performance

5. Development of ~~Tools for measurement~~ of the effectiveness of various info systems.

Controlled experiments with subject groups — statistical techniques required

to measure? (what?)

- no. of references produced
- unit of productive work resulting
- total time spent for literature researching the same tasks.

6. Derive expression for figure of merit of the systems —

7. Cost functions

List of things IR system should do:

contingiose weighting yet

— no built in bias
criteria should

could give limitations on criteria — ~~don't~~ criteria schedule, variability of general system

different level of criteria (the ranking question)

eg) 1. criteria on machine characteristics — retrievable items

2. how [illegible] questions posed

3. how considers a question — eg) degree of strength required for question

4. how worthwhile is it to have the info.

potential sound activity should determine the requirement

How long to store items? (Werner)

What materials to acquire initially (value ranking)

~~Measures of Effectiveness~~

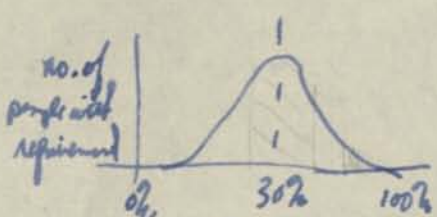
Development of Criteria & Measures of Effectiveness of Info Storage & Retrieval Systems

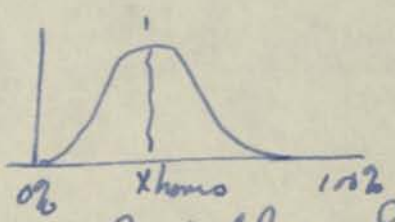
1. Want standards of measurements which can be applied to any info retrieval system in order to achieve some meaningful comparisons (eg. as done with automobiles or type speeds for computers)
   a) might develop standard question forms or interrogations in order to measure response times, % relevancy, & effectiveness.

2. Want standards of ~~terms~~ nomenclature for various parts of the info systems (eg. what constitutes a file item, a descriptor, etc.)

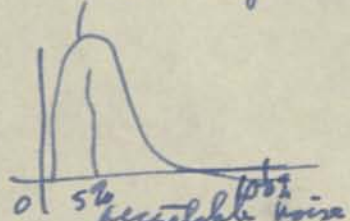
3. What general models of info retrieval system can be constructed as an aid to studying the ~~nature~~ characteristics of a particular system?

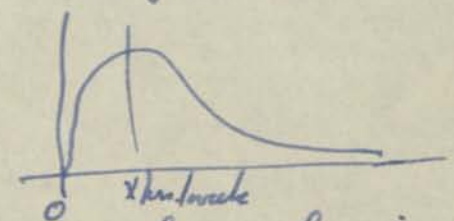
4. What are the needs of the user, & ~~the~~ what is the distribution of needs among the users (eg. 1% want total coverage, 1% want 1% coverage, 50% want moderate recovery coverage)





. . . . — etc.



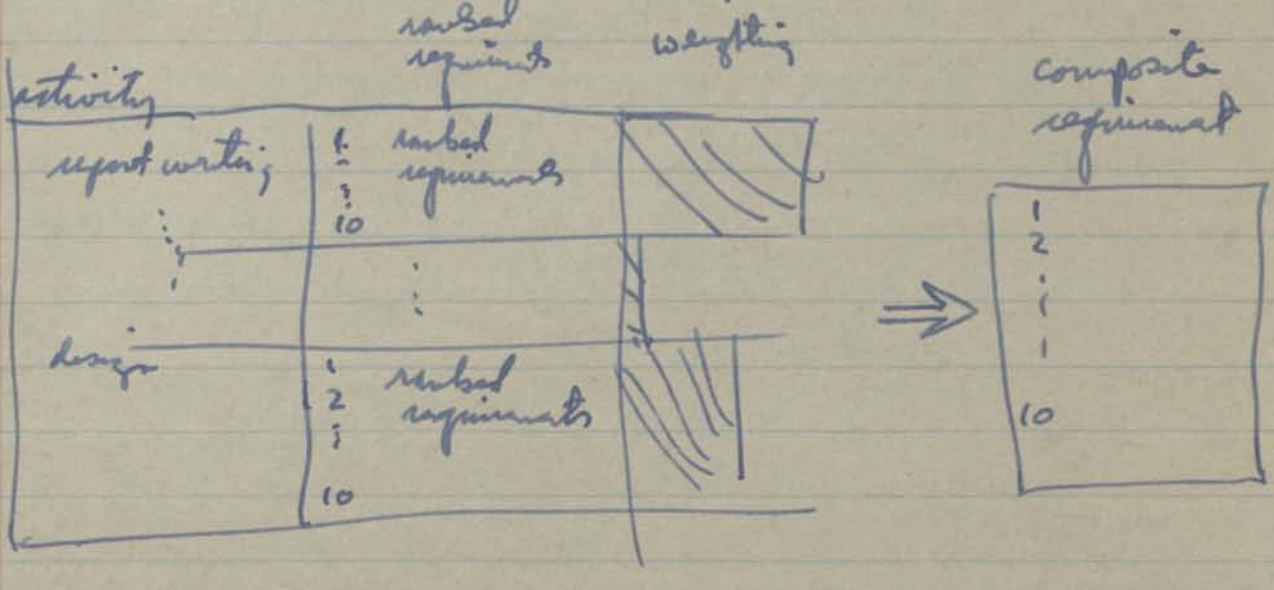


Develop these distributions for the various needs — by empirical studies.

Measurements to be Made

1. Composite Relative Weightings or rankings of the system parameters (requirements)
   Done by performing pair-wise comparisons of the parameters we provide, as well as including other parameters he might think of.

2. Relative weightings or rankings of the system parameters (requirements) for each of the main types of activities.



Sub: Limitations & assumptions

In the name of expediency, some limitations & simplifying assumptions must be made about our problem. Here are a few limitations that will probably be enforced:

1. We will concern ourselves with document retrieval systems rather than information retrieval systems, with the documents being conventional books, journals, & reports.

2. The evaluation of competitive systems will assume that each system starts with exactly the same file material, & that the system provides abstracts as a search product.

3. No special attempts will be made to generalize the E.E. requirements to engineers or scientists in general. Our major contribution will be to show what requirements are important, what can be measured, & what methodology is to be used.

4. The systems are to be considered for specific searching only, not for current-awareness reporting.

5. The interviewed users will be active research workers below the level of full-time administrative or managerial personnel (e.g. directors, managers)

6. A user's requirements will probably be different for each of his activities (e.g. report writing, equipment design, etc.). However, we will derive only a single set of requirements for each user -- reflecting his composite requirements for all types of activities.

Aug 14, 1961

Determination of an Upper Bound to the Worth of IR Systems

Assuming that the informational habits of workers in applied electronics can not be grossly altered, at least not rapidly, even if this could be shown to be economically ~~too~~ desirable, it should be possible to form an idea of ~~the~~ an upper bound of the economic worth of informational efforts supporting a given activity. Such a bound would be sought as a possible means of determining the relative weighting to be given to the informational needs generated by each type of research activity being considered.

In the first place, each such activity might be assigned a worth ~~for~~ to a given research community to be served by a certain informational system by noting how many salary dollars are spent in this activity during the period under consideration (yr, month, etc.). The next factor to take into is the role that information plays in this activity. The two factors, salary dollars spent and sensitivity of success in the activity to lack of information, would then be combined to modulate the weighted informational needs generated by the activity before they are combined with similarly treated requirements stemming from other research activities of the community.

In an attempt to delineate clearly (hopefully) how I think my idea should be applied, let me try to represent it in a symbolic form.

Let R^i_o ---- R^i_n be the informational requirements of the i^{th} research activity. These needs would have weightings W^i_o ---- W^i_n respectively. Let the salary dollars spent on a given research activity be D_i; where

$$D_i = \sum_{j=0}^{j=m} S_j H_j$$

; S_j is the salary of the j^{th} man

H_j is the time spent on the activity by the j^{th} man.

$m \geq J \geq 0$

Further, let L^i_o ---- L^i_n be the leverages on the success of the i^{th} activity of the

Further, let L^i_o ---- L^i_n be the leverages on success of the i^{th} activity of meeting the requirements of the activity R^i_o ---- R^i_n.

The unadjusted weights for the requirements will be $R^i_o W^i_o$ ---- $R^i_n W^i_n$. If these weights relative to the weights of those for other activities are directly proportional to salary dollars and to the leverage factors,

we shall have a set of ~~reo~~ weighted requirements for the i^{th} activity of

$$D_i \left[R_o^i W_o^i L_o^i \; ---- \; R_n^i W_n^i L_n^i \right]$$

If D is the total salary expenditure for all activities the value for ~~any given requirement would be~~ the

$\sum_{i=0} \frac{D_i}{D} R_o^i W_o^i L_o^i$ o^{th} requirement would be

$$\sum_{i=0}^{i=p} \frac{D_i}{D} \cdot R_o^i W_o^i L_o^i \qquad p \geq i \geq o$$

If it is decided to represent this requirement as a distribution, the summation would be replaced by a distribution function. ~~Here the $\frac{D_i}{D}$ factor~~ It has been tacitly assumed that all D men performing the same job will have the same requirements and that each of these requirements can be ~~measured by~~ by represented by a single number. In fact each may have to be pictured as a distribution function.

From the look of this problem as roughly pictured above the burning question would appear to be to focus attention on as few essential requirements as

possible. What might these be? Possibilities that come to mind are:

(1) Response time to ~~first~~ reply (a) first reply
(b) 90% of all replies,
~~(b)~~(c) all replies.;

(2) ~~A~~ Percentage of irrelevant material delivered;

(3) Amount of relevant material in the file that is missed;

I wonder if even browsing can't be covered by these characteristics alone. ~~Only~~ The above requirements only cover ~~the matter of~~ the manner in which the document retrieval system responds to ~~some~~ questions. ~~Such~~ To answer ~~this question an inquiry~~ requires that the posing of queries be looked into.

For instance one may easily discover the performance of a system to a query of the specific sort, "I want all documents that fall in a given index class." Presumably when the request~~ion~~s can be framed in terms of the index language ~~the~~ its the system's performance on requirements #2 and 3 should be perfect, ~~which~~ ~~I~~re I~~f~~ browsing is to be effective the first response must be exceedingly fast.

I should think that another important characteristic of a document retrieval system to which attention must be given is the ease with which the user can frame his query. That is to say, the ease with which he can translate from his own language to the index language of the system. It is assumed that the user is capable of framing the proper questions in his own language. In practice a librarian, for instance, helps the user greatly in this regard, to such an extent, in fact, that ~~little~~ the operation of automatic document retrieval directly by the ultimate user may prove most difficult, may require his special education, or may necessitate the employment of an intermediary, a ~~librarian~~ librarian in effect.

This line of reasoning seems to focus attention squarely on the translation process — from the user's language to the index language of the document retrieval system. If, when this translation has been performed, the document retrieval system is not able to function because of too coarse an index, the deficiency must be charged to the system. This charge could be in terms of the amount of irrelevant material which ~~in this~~ such a case would be high.

As an aside, assuring the seeker that his item is in his file would be very valuable.

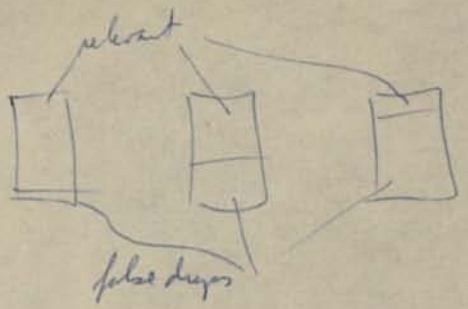
The amount of harm that a coarse indexing system does depends on two factors:

(1) Whether or not the user wants information in a finer category than the index provides;

(2) The nature of the file material.

If the user can not be very specific in framing his search ~~ques~~ question in English, presumably because he doesn't know much about the subject of his search, he will find it relatively easy to translate to the index language which in turn should be fine enough in its categories to return ~~the~~ documents that are of ~~k~~ use to him. Provided that these documents ~~sa~~ inform him rapidly about the subject so that he is subsequently ~~adj~~ able to frame more specific questions he has not suffered from an overly coarse index. However, when he is able to pose question which are specific enough that they are limited in translation into the index language by the latter's coarse structure, the nature of the file material and its ability to provide clues for ~~its or~~ the searching of itself will determine ~~his~~ the progress of his search.

Jackie C-333

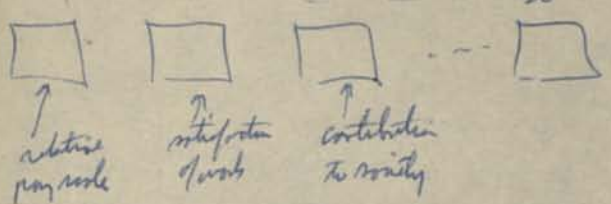


pair-wise comparisons

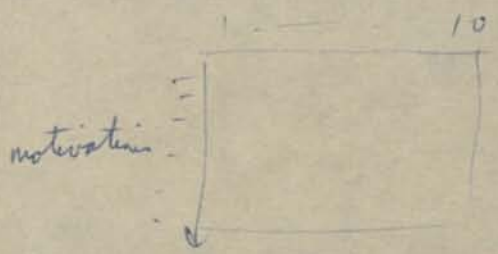
Give a user several search results, each of which is a data unit different values of several elements. Ask user relative worth of products. - various units

Why do students leave courses?

list of cards w/ separate statements of reasons for changes



1. read each card & comment as it applies to yourself - tape records.
2. basic scale 0-10 (greatly influenced to most) how would you rate each of these?



stop! scaling - 10 is not twice as much as 5. can only hope to get a ranking.

e.g.) "When I start new research, I go to the library, ---
I go to someone in the field, ---

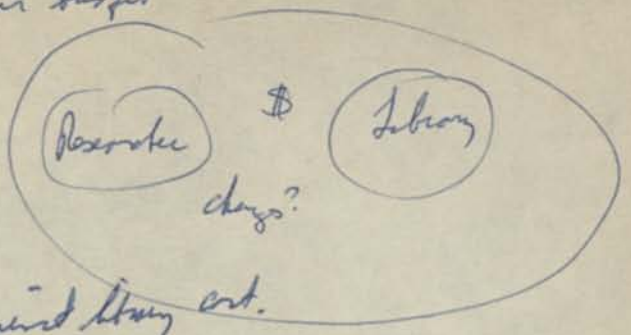
Critical Incidents technique to be used - with personal interviews.

We should produce results that can serve as the basis for action - eg) act toward maximizing in industry, or some corporate location.

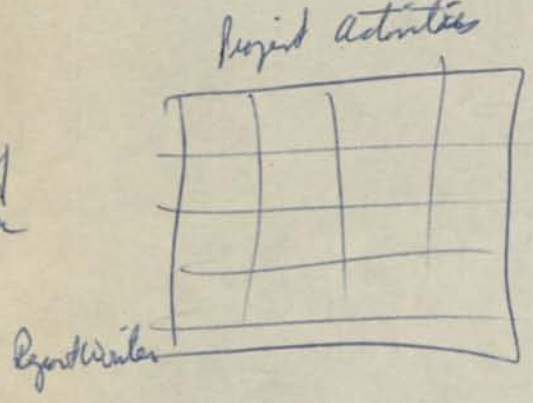
Addl. Tasks Describe Capabilities of I.R. Systems.

Keep Total I.R. dollar budget constant.

retrievable { title:
author:
corporate:
I.R.



Balance against library cost.



Hypotheses: groups which are important to their publication production.

Use salary data to weight needs — or use span of control?

Prob. of critical variant techniques: How to discover or consider the routine requirements taken for granted, which never go critical?

Research: IR vs Dc. Retrieval

Jobsic thinking of 100 industry surveys.

TASK 1 DEVELOP AN INITIAL LIST OF USER'S REQUIREMENTS TO BE STUDIED.

10 July

1. Initial list of questions has been framed to indicate the types of inf. sought. Questions are now being re-framed in accordance with good survey or interview technique. Questionnaire may be almost self-administering.

"

2. Preliminary list of SRI test subjects has been prepared, including 135 EE's in many specialty fields and many levels of responsibility.

"

3. Visit arranged to Benson-Lehner to find what they feel are important user requirements. They design and build I.R. equipment and are therefore very interested in what the user's requirements are, and how they are weighted. They are also interested in judging the performance of I.R. systems and have thought about figures of merit. It is also quite possible that they might assist with the survey by allowing their E.E. employees to be interviewed--thus providing some information on the correlation between industry and research institute engineers' requirements.

"

4. Pertinent published material has been reviewed. There is very little of immediate application. Other works to be followed up include: (1) an IBM-Lockheed study of the value and importance of I.R., (2) Survey of user's requirements made by Bob Howerton -UCRL-Livermore, (3) Survey of user's requirements by Bell Labs (4750 questionnaires), (4) Howerton's views on relative importance of the various requirements, (5) Heilprin's views on some.

14 July

5. The visit with Benson disclosed additional points which might be included in the survey. He also volunteered his R+D group (20 to 25 people, including about 5 applied electronics researchers) as test subjects for the survey work. Benson disclosed details of their new unannounced I.R. system (COMAC-2) & suggested that this would be a good candidate for our tests of the evaluation procedures. Arrangements have been made to obtain more operating information from Documentation, Inc., in Washington.

24 July

6. Questionnaire was received from Bell Labs; no study or report has been made by them of the results.

TASK 2 DEVELOP SCALAR AND PROBABILISTIC MEASURES OF AS MANY OF THE REQUIREMENTS AS POSSIBLE WITHIN THE LEVEL OF EFFORT OF THIS STUDY.

10 July 1. Awaiting results of the interviews to find out what requirements can be described analytically, what requirements can be described by ranking, and which requirements can be described only with judgement or opinion.

" 2. The actual measures will be obtained after analysis of the interview data.

" 3. The methodology (primarily by interview) and the subjects (SRI E.E.'s in all specialty fields) have been established.

13 July 4. Current thoughts are to use a test group of 4 different types:

1. SRI - Specialty Field #1
2. SRI - " " #2
3. industry - Specialty Field #1
4. industry - " " #2

this should show differences between specialty fields as well as differences between SRI & industry in general. The survey, hopefully, will be primarily by questionnaires, with a few interviews in depth.

24 July 5. thinking about the possibility of testing more hypotheses with the survey than the SRI-industry, and specialty field differences.

6. Paul Howerton did not specifically measure users requirements, but has found in practice that users prefer to receive all relevant material plus about 20% marginal information --- rather than only the relevant information. (Psychology!)

7. Paul Howerton also found that the required response time was strongly related to the age of the material requested.

TASK 3 DEVELOP THE RANKING OR RELATIVE WEIGHTING FOR AS MANY OF THE REQUIREMENTS AS POSSIBLE WITHIN THE LEVEL OF EFFORT OF THIS STUDY

10 July 1. The actual rankings or weightings will be obtained from the results of the interview data.

24 July 2. Heilprin, CLR, feels that the most important parameters are: cost per unit page delivered; access time per page; and quality of reproduction.

3. Miller, Documentation Inc., feels that cost is the only parameter, & that all systems are essentially equivalent in other respects.

TASK 4 DEVELOP A ROUGH SET OF CRITERIA AND A PROCEDURE, THAT COULD BE APPLIED TO EXISTING SYSTEMS IN ORDER TO REACH TENTATIVE CONCLUSIONS ABOUT THEIR PERFORMANCE.

10 July 1. Data is being collected and plotted to show the practical bounds that might be imposed on an I.R. system for file size and file input rate requirements. This is being approached from the viewpoint of I.R. systems for an individual, for an industrial organization, for a specialty field, for a special information center, and for the world's total literature.

2. Lists of received periodicals have been obtained from Bell Labs, Benson-Lehner, Ampex, IBM-San Jose, Lockheed, G.E. Microwave Lab-Palo Alto, SRI. This type of data will allow some statements to be made about parameters of I.R. systems for research organizations.

TASK 5 DEVELOP A MODEL OF A REPRESENTATIVE SIMPLE INFORMATION RETRIEVAL SYSTEM

10 July 1. Arrangements have been made to talk to Heilprin (CLR) who has done some modeling in this area. Some initial and crude models have been developed.

24 July 2. Indications are that Bob Hayes, Electronic, Los Angeles, is the only person who is currently working on I.R. models.

3. Some Time & cost data for model coefficients has been offered by Paul Howerton.

TASK 6 TEST THE REQUIREMENTS, CRITERIA, AND EVALUATION PROCEDURES ON SUCH REPRESENTATIVE SYSTEMS

11 July

For planning purposes, serious thought has been given to evaluating the following systems (representatives of several fundamentally different approaches):

1. FMA Filesearch (high speed roll microfilm selector)
2. Jonkers' Termatrex (peek-a-boo interim-punched cards)
3. Benson-Lehner COMAC-2 (IBM card system)
4. McBee edg-punched card systems

these additional systems might be evaluated if enough operating information can be obtained:

5. Conventional IBM card system
6. Eastman Kodak Minicard
7. Typical general-purpose computer system
8. Special-purpose magnetic tape recording system (unspecified type)
9. Magnavox Magnacard

TASK 7

DEVELOP PLANS FOR A RESEARCH STUDY TO BETTER DESCRIBE THE USER'S REQUIREMENTS, AND TO IMPROVE THE CRITERIA AND EVALUATION PROCEDURES

2-3/July

1. How to measure a research worker's productivity?
2. Relationship of research productivity (or effectiveness) to the amount of source material furnished to the research worker?
3. Determination of the significant differences in information requirements of: physicists vs. chemists, etc.
   people with different academic degrees
   " " " specialty fields
   " " " management levels
   " " " organizations (industry, university, etc.)
   basic vs. applied vs. testing, etc.

Development of elemental time + cost data to be used for modelling + econ. studies.

Comments on NSF Tasks in the light of SW memo of Aug 10

Task 1 - List of requirements to be studied — but how do we know what these are until we have conducted interviews? We might guess wrong and so be warping the study. Do we really mean that we are going to list our questions or say something about our interviewing technique?

Possibly we might try to boil down to as few terms as we can & what we think the essential characteristics of any requirements to be. In essence, then, we are saying something about the metric for the requirements. For example we might list:

(1) Delay to get 1st reference,
(2) Delay to obtaining 1st document,
(3) Delay to obtain final reference,
(4) Delay to securing ~~final~~ last document.
(5) Percent irrelevant material,
(6) Percent useful material overlooked.

Task 2 - Develop measures of as many of the requirements as possible — If my suggestion, is true that the ~~acting~~ research activities are in fact the ~~the~~ real determinants of informational needs ~~is true~~, then a set of interviews should seek to discover the relation between them. It ~~might~~ would not be possible to generalize from these data about the informational needs of a company or industry. For this to be done the number of

man-hours spent in each activity for the organization concerned would be needed. ~~The obtain~~ However, the obtaining of this man-hour data would be a reasonable task for those who wished to apply SRI's fundamental data about requirements. If this course of action is followed ~~the~~ our work under task 1 would be to define the research activities on which attention is to concentrate in a search for informational needs.

Task 3 - Develop the weighting for as many requirements as possible ~ It seems to me as if each research activity, as defined (suggestion) in task 1, will produce a set of requirements. ~~Some of~~ It may well be possible to assess the ~~weighting~~ relative weighting that should be assigned to each of these. This would be attempted, presumably, as a result of the interviews. However, ~~each set of rq~~ the weights associated with ~~the~~ each ~~resea~~ set of requirements will have no known ~~to~~ value with respect to those assigned to other sets even though some of the requirements ~~will~~ may be common to the two sets. If ~~a composite wg~~ weightings are to be established for a composite set of requirements derived from ~~considering~~ simultaneously considering a number of research activities, it will be necessary to know the relative worth of these activities.

Task 4 ~ Develop a rough set of criteria & a procedure for evaluating the performance of an informational system ~ This might be done if two preliminary tasks can be accomplished. The first would involve the ~~assumption of a~~ assignment of a mix among the research activities and a designation of relative worth among them. From these two assumptions a set of weighted requirements, stated in user's terms, would have to result. The second ~~task~~ pre requisite task would be the creation of a set of criteria, stated in system terms, from the composite set of user requirements. Finally, the procedures for creating ~~the~~ a single figure of merit for the system in the face of the criteria and measured or calculated performance would be followed much as outlined in the proposal.

Task 5 ~ Develop a model of a simple information retrieval system ~ I think we should start with a model of ~~an~~ a document retrieval system. The methods of indexing to the documents, the manner in which acquisitions are handled, the way in which items are deleted from the file, and the methods by which inquiries are handled would still be subjects considered in the model.

Task 6 ~ Test the evaluative procedure ~ this would involve the following steps in addition to those already covered:

(1) Determine performance of the representative system chosen;
(2) State the criteria in system terms (task 4)
(3) Apply evaluative process

Task 7 - Plans for future research. ~ I'd advocate use of collected notes of all project workers — consolidate the ideas in these at intervals — as well as a project diary (already started under some tasks) — how about task 7?

Henry Goodwin - Battelle - Spec Lib Nov 1959, pp. 443

"there are a no. of things an eng. or sci. would like from an ideal info service, & the following lists some that appear to be important:

1. To receive the technical info. desired

2. To receive it when he wants it - neither before nor after.

3. To receive it in the briefest form possible.

4. To have it presented in order of importance.

5. To receive necessary supporting info. w/o asking for it.

6. To know the degree of reliability of the info.

7. To know the authority (source) for the info.

8. If he doesn't receive the info, to be told positively that it does not exist.

9. To receive the info with as little effort on his part as possible - automatic in most cases.

10. To be screened from undesired info or from desired info at the wrong time.

2 types of responses not satisfying:

1. a list of references in place of info. desired
2. to be told, "You can probably get the info at ...."

Consider the types of info that an eng. or sci might want. Five diff. kinds of info requirements are:

1. To be kept informed in detail on new information in certain subject areas.
2. To be informed when especially valuable new discussions, analyses or interpretations appear that do a better job of organizing existing info in a subject area (no new info.)
3. To be kept informed in general (news type info) in other subject areas.
4. To find specific answers to specific questions, or to find info on specific subjects (Range in complexity from simple facts to detailed eng. help involving analysis & judgment)
5. To have called to their attention new & stimulating developments or facts in fields in which they are not presently interested, but in which they might be interested if they knew of new facts or developments.

This is the way → interests users are broadened. — this is currently done on a random basis.

Irwin Goldman — Wed - Jan. 2

NAS - NRC Committee on info retrieval for NSF — Due Friday Jan 13 or sooner

NSF sponsoring WRU effort
WRU wants to expand coverage (NSF existing coverage $200,000)

GE - proposes evaluation of their uniterm system vs. WRU
($1/4 mill test)

Ramo Wooldridge -

England -

Council should be inviting proposals on develop measures of effectiveness, rather than hardware (as a means of judging what's going on in the hardware)

criteria development - aims
: attain of universal or extendable
adaptable from 1 EDP appings to another
methods of simulation

Hard sciences especially of interest
validity of answers
difference of synthetic vs real questions
cost
speed - efficiency (relevance)
exhaustive
noise level
core material vs. fringe material
how much do you miss by browsing

X

How to measure how close we're getting to our desired goals.

Now inviting proposals - prelim. proposal requested.

Bill proposes, "What is role of tech library at SRI?"

Irwin references, Battelle study of use of Dupont Uniterm Files

might be : Phase 1 - develop criteria
" 2 - Navy Hydrographic office study as a concrete example.

NSF advises to get started as soon as possible. - but don't know of time limit

concentrate on product development & applied engineers.

4-6 pages of proposals - outline of thoughts on approach & scope —
man-yr. level, ± cost.

GTE
Univ. Univ, RA.

Question Problems

1. Diff. kinds & complexities of questions (are these as parameters for both cases?)
2. Diff. degrees of value for information overlooked
3. – possibly some advantage to having some interviews in depth.
4. Given many items to read – how would user read it. (e.g. 5 journals for 20 yrs. or 20 journals for 5 yr.) ~~a~~ or given a list of library or info services -- search, auto-routing, etc. – what would you read on each function?
5. Rapid feedback response may be desired – how to measure? (e.g. quick looks, dribbling output, batched output) → a route question
6. Do users engage in flights of fancy?
7. Different approaches: benchmark problem, decathalon scoring.
8. Are there significant differences between organizations (IRI, industry, govt. lab, etc.) or between people (age, degree, job, discipline, etc.)?
9. Sample size required? Confidence level for various sample sizes in 30-150 range?
10. Generate picture of what retrieval systems can be expected in 3-5 yrs.
11. How to measure social effects within an org.?
12. How to handle different accounting procedures for different systems (govt. library, industry)
13. Queuing considerations for modelling?
14. How do applied electronic engineers relate to other workers? (How many electronic researchers, electrical engineers, total engineers?)
15. Forms of requirements (continuous functions, ranking, singular statements)
16. Does ASTIA keep a record of their need requests?

Rosen.

Aug 14, 1961

Have decided on what one wants to do
Know input & output
Have no expert at home.
Seek an expert who hopefully will give one reference to the right articles.

C 119.

Effort to unearth the info needed

case a — where the is only one answer

case b — where each new piece of info adds less & less to ones knowledge but costs more & more to obtain.

Items being worked on for NSF project

1. Interviews of a sample of a particular segment (SRI) of the user population. (not too much imagination being shown by people)
2. Modelling of an information retrieval system. (not using Lefkowitz fully yet).

Items that will not receive attention for some weeks

3. Formulation of criteria from requirements;

4. Methods of describing system performance;

6. Means of evaluating system performance in the light of the criteria developed.

Items that will receive concentrated attention only toward the end of the project

7. Articulation of future research program.

Should utilize the imagination and goodwill of Irvin Goldman in a constructive way on the project.

Comments on Reading Borme's NSF File Aug 10, 1961.

June 26 memo (Knicaird, Peterson, CB meeting)
Is a sample taken from SRI alone representative in the E.E. field in say, the category of age?

June 29 memo — Description of User Population.

Is a distinction to be made in selecting the user population among EE's who are doing active research, who may be expected to be heavy users, and those with the necessary academic qualification who are let us say in essentially administrative work?

I'd be more concerned that SRI's work diet grossly influenced SRI men's requirements for info than I would that the population selected from EE's at SRI was basically from a similar one chosen at say, LMSD.

We seem really to be talking about DOCUMENT retrieval — let's call a spade a spade, enough of this euphemism

July 7 Lefkowitz memo.
The questions raised about the population's awareness of his own library tread into the area of general info that CB has ruled out.

July 26 memo from Lefkowitz — Aug 10, 1961

How do we differentiate between expressed needs or needs ~~to~~ ~~if~~ inferrable from present actions and actual needs of users? In order for a user to convert an actual to a present need his use of informational facilities may have to change radically and this against social and organizational pressures. For instance, he may learn that he needs more data on a given subject but he may hesitate to be away from his desk for long periods in seeking the information for fear that his boss will feel that he is not applying himself diligently enough

I trust we are using the library usage attribute as a measure of the type of person being interviewed not as a factor indicative of the interviewee's requirements for information. I'd like to see this point explored carefully.

July 27, 1916 from Lefkowitz

I'm sure that most E.E's have not thought a great deal about the informational needs but I believe that it has been firmly concluded that nothing is to be gained by interviewing librarians especially if they happen to be doing a poor job of fulfilling the needs of the user.

General Methods for Determining User's Information Requirements.
C.B. memo Aug 1.

User's Information Environment — Constraints on use of time & amt. of money that may be spent on info. retrieval.

Present Info. Sources — set a min. standard of performance for any new system. operating statistics?

The User.

Are there no points of diminishing return as far as the research worker is concerned in each phase of his project that can be forseen either (a) by the nature of the problem or (b) by the amount of time his work allows him to spend on info retrival.

Sample Mix Considerations. C.B. — Aug 1.

As long as the proportions of each type of user ~~are~~ in the total population are known, surely it dosn't mean that the sample sizes taken for each segment have to be in this same proportion as long as they are large enough to yield results of the statistical accuracy called for.

Is the distribution of E.E's and applied electronic engineers, in particular, the same by size of industry, for instance, as for the general engineering population? (DOD-industry survey give slightly different figures)

Initial List of User's Requirements C.B. Aug 7, 1961

It looks to me as if many of the listed items are pertinent to the I.R. System and not primarily to the user.

N.S.F. proposal. — notes on re-reading the proposal.

1. Have we yet got in touch with Irvin Goldman?

Scope & Method of Approach

User Requirements.

1. Review findings of those research men who have attempted to discern the requirements of various populations of users. — be sure to not limitations involved in data collected. When gaps apparent consult selected, well-informed users The needs we are seeking must be in the context of achieva perturbations in the present IR system. Question: How does one state the cost to the user of the present system as a base from which to ~~repeat~~ give the incremental costs of improved services that might be reasonably be desired and paid for?

   The fact that different users can in fact pay different amounts for their info. services will automatically result in a probability density function as an expression for each requirement merely as a result of a fixed price for the service.

   If data can not be obtained concerning what

each element surveyed is willing to pay for a given service, ~~a fixed~~ an arbitrary price might be stated to each person interviewed in seeking a ranking from him of his requirements. A recalibration using the man's salary scale possibly as the factor could then be applied.

~~User's will have diff~~ The weighting of users requirements will vary with the subject matter of the file. In other words we should try to normalize the relation between user & file subject material in order to remove it as a factor in the equation otherwise there will be too many combinations of ~~users~~ types of users & files for ~~each~~ each of which combination there will exist a separate weighting of requirements. Perhaps the file-user combinations might be reduced to manageable proportions by conceding only two types of files relative to ~~the~~ each user, in this case an applied electronics engineer, viz: (a) in his field; (b) outside his field.

(2) Translation of Requirements into Criteria.

Question: ~~If the emphasis given to the requirements of each group of similar users in the total population is determined both by the users weighting~~

In combining ~~user~~ the requirements of one set of users in the total population of ~~all~~ users with those of the others surveyed is it satisfactory to apply the factor representing ~~that~~ the ~~size~~ of the set in the total provided that the rating of the requirements had been gathered against a stated price for the service. No! I imagine that the ~~probable salary~~ price each is willing to pay must be applied.

~~$W = f(W_i, S_i, N_i)$~~ ; ~~where W is the weight of each requirement~~ ~~one~~ Weight of the j^{th} requirement is

$$\sum_{i=0}^{i=n} W_i = \sum_{i=0}^{n} f(W_i, S_i, N_i)$$; where W_i is the weight of this requirement to the i element in the population
S_i is the salary (relative) of the ith element
N_i is the size of the element.

System Performance Calculation Of.

(1) How does one describe system (present & slightly improved) performance to users being surveyed?
(2) What parameters are of greatest concern.
(3) What system will be chosen for modelling? What

are the random variables that can be ~~xxxx~~ used in a simulation? Has this been done before — by IBM, SDC Shaw? Are there any simple analog techniques that can be used?

Discussion ē Shapiro (E) reveals that considerable difficulties exist in scaling properly the various parameters that may perhaps be generated randomly in an analog fashion in order to make them fit the true scale of the simulation. This scaling, if needed, is done much better by digital means.

[Must distinguish between document retrieval ~~and~~, fact, and idea retrieval!]

Aug 16, 1961

The Game of Using Document Retrieval Systems.

When the information seeker is faced with the task of obtaining certain data, he normally has available a set of possible sources. If he is to conduct his search as a reasonable man would, he should distribute his efforts among the various facilities in accordance with the probability of getting the desired information from each and in recognition of the difficulty of securing the data from this source. In playing this "game" the seeker will size up these factors and will gauge the effort he puts into finding information from each source according to his evaluation of the relative worth to him in this instance of:

(1) Speed in getting the data,

(2) Certainty of getting the data from a given source,

(3) Effort spent in obtaining the information.

~~In the first place, if we~~
In the first place we should probably distinguish between the two main types of information that are normally sought. One ~~ty~~ kind ~~is~~ of search can be satisfied only by one piece information such as ~~the~~ a specific name or the numerical value of the melting point of a certain ~~com~~ compound. ~~Es~~ In this case no other information is worth anything. In the other general type of search data is sought about some ~~more general~~ particular subject but in this instance each piece of information is of some value. If one wants to know how to build a bookcase

even data about the drying qualities of chinese lacquers may be of some slight use. However, as one's knowledge ~~of the subject~~ increases of the subject under ~~one~~ investigation the amount of information that each new piece of data adds to that already in hand decreases, probably in some logarithmic fashion. Data that duplicates some already received adds essentially no information.

Attention has been focussed on the ~~way~~ information content of the data that the seeker obtains from the document retrieval system in order to provide a standard against which the effort spent in the search can be gauged. In practice this effort may be expended entirely by someone other than the seeker himself and may involve very

menial tasks. On the other hand the search effort may involve the searcher himself and may entail hard mental work on his part. A distinction can probably best be made between these two by referring to the first under the category of cost and to the second ~~under the~~ by the term effort.

Let us consider for the moment a researcher at SRI who wants information about some subject in general. Let us assume that he has three principal libraries to which to turn: SRI, Stanford University, and University of California at Berkeley. He may turn to the SRI library first in hopes that he can obtain his data there rapidly. Since he may not rate his chances ~~very~~ very great of getting it at all from this source, he may

instigate a search at ~~st~~ the Stanford University Library where he may hope to find the items sought with the minimum effort compatible with a given ~~deg~~ certainty of success. On the other hand he may eschew these first two courses and put all his effort into a search at U.C. on the impression that his chances of success are greatest for such action. Naturally, various mixtures of these strategies may appeal most to the seeker in the light of his evaluation of his needs and ~~his est~~ on the basis of his estimates of the efforts involved and the chances of success in each case.

Aug. 15, 1961

The Use of an Expert in Conducting a Search.

I. Starting Point.

Assume that the ~~docum~~ information seeker knows roughly what information he needs but does not know where to find it. The seeker, often through several inquiries, locates an expert or very knowledgable person in the general subject of his interest. This expert, if he turns out to be the right person, directs the seeker to the appropriate index categories. Perhaps it would be better to ~~say~~ note that he tells the seeker exactly how to frame his question in English. It is a pure bonus if the expert also is able to perform the translation from this question to the index

number of any particular library or to a shelf location. However, for the sake of the discussion it might be best if we assumed that the expert could not do this since we don't know to what libraries we have access.

The other thing that an expert can do is to direct the seeker's attention to general information about the subject of his inquiry. By reading this information it is hoped that: (a) the seeker will be able to frame his own inquiry accurately enough to lead him to what he wants; ~~(b) to get to know~~ (b) the seeker will learn enough about the subject so that he may again consult the expert, this time to come up with a properly stated inquiry.

Aug 14, 1961

Determination of an Upper Bound to the Worth of IR Systems.

Assuming that the informational habits of workers in applied electronics can not be grossly altered, at least not rapidly, even if this could be shown to be economically ~~too~~ desirable, it should be possible to form an idea of ~~the~~ an upper bound of the economic worth of informational efforts supporting a given activity. Such a bound would be sought as a possible means of determining the relative weighting to be given to the informational needs generated by each type of research activity being considered.

In the first place, each such activity might be assigned a worth ~~for~~ to a given research community to be served by a certain informational system by noting how many salary dollars are spent in this activity during the period under consideration (yr, month, etc.). The next factor to take into is the role that information plays in this activity. The two factors, salary dollars spent and sensitivity of success in the activity to lack of information, would then be combined to modulate the weighted informational needs generated by the activity before they are combined with similarly treated requirements stemming from other research activities of the community.

In an attempt to delineate clearly ~~how~~ how I think my idea should be applied, let me try to represent it in a symbolic form.

Let R_o^i ---- R_n^i be the informational requirements of the i^{th} research activity. These needs would have weightings W_o^i ---- W_n^i respectively. Let the salary dollars spent on a given research activity be D_i; where

$$D_i = \sum_{j=0}^{j=m} S_j H_j \quad ; \quad m \geq j \geq 0$$

S_j is the salary of the j^{th} man

H_j is the time spent on the activity by the j^{th} man.

Further, let L_o^i ---- L_n^i be the leverages on the success of the i^{th} activity of the

Further, let L_o^i ---- L_n^i be the leverages on success of the i^{th} activity of meeting the requirements of the activity R_o^i ---- R_n^i.

The unadjusted weights for the requirements will be $R_o^i W_o^i$ ---- $R_n^i W_n^i$. If these weights relative to the weights of those for other activities are directly proportional to salary dollars and to the leverage factors,

we shall have a set of ~~reo~~ weighted requirements for the i^{th} activity of

$$D_i \left[R_o^i W_o^i L_o^i \; - - - - \; R_n^i W_n^i L_n^i \right]$$

If D is the total salary expenditure for all activities the value for ~~any given requirement would be~~ the

$\sum_{i=0} \frac{D_i}{D} R_o^i W_o^i L_o^i$ o^{th} requirement would be

$$\sum_{i=0}^{i=p} \frac{D_i}{D} \cdot R_o^i W_o^i L_o^i \qquad p \geq i \geq o$$

If it is decided to represent this requirement as a distribution, the summation would be replaced by a distribution function. ~~Here the $\frac{D_i}{D}$ factor~~ It has been tacitly assumed that all D men performing the same job will have the same requirements and that each of these requirements can be ~~measured by~~ represented by a single number. In fact each may have to be pictured as a distribution function.

From the look of this problem as roughly pictured above the burning question would appear to be to focus attention on as few essential requirements as

possible. What might these be? Possibilities that come to mind are:

(1) Response time to ~~first~~ reply (a) first correct reply
(b) 90% of all replies,
~~(b)~~(c) all replies.;

(2) ~~A~~ Percentage of irrelevant material delivered;

(3) Amount of relevant material in the file that is missed;

I wonder if even browsing can't be covered by these characteristics alone. ~~Only~~ The above requirements only cover ~~the matter of~~ the manner in which the document retrieval system responds to ~~simp~~ questions. ~~Such~~ To answer ~~this question an inquiry~~ requires that the posing of queries be looked into.

For instance one may easily discover the performance of a system to a query of the specific sort, "I want all documents that fall in a given index class." Presumably when the request~~ion~~s can be framed in terms of the index language ~~the~~ its the system's performance on requirements #2 and 3 should be perfect, ~~while~~ ~~I~~ne If browsing is to be effective the first response must be exceedingly fast.

I should think that another important characteristic of a document retrieval system to which attention must be given is the ease with which the user can frame his query. That is to say, the ease with which he can translate from his own language to the index language of the system. It is assumed that the user is capable of framing the proper questions in his own language. In practice a librarian, for instance, helps the user greatly in this regard, to such an extent, in fact, that ~~little~~ the operation of automatic document retrieval directly by the ultimate user may prove most difficult, may require his special education, or may necessitate the employment of an intermediary, a ~~librarian~~ librarian in effect.

This line of reasoning seems to focus attention squarely on the translation process — from the user's language to the index language of the document retrieval system. If, when this translation has been performed, the document retrieval system is not able to function because of too coarse an index, the deficiency must be charged to the system. This charge could be in terms of the amount of irrelevant material which ~~in this~~ such a case would be high.

Assuring the seeker that his item is in the file would be very valuable.

The amount of harm that a coarse indexing system does depends on two factors:

(1) Whether or not the user wants information in a finer category than the index provides;

(2) The nature of the file material.

If the user can not be very specific in framing his search ~~ques~~ question in English, presumably because he dosn't know much about the subject of his search, he will find it relatively easy to translate to the index language which in turn should be fine enough in its categories to return ~~the~~ documents that are of ~~t~~ use to him. Provided that these documents ~~sa~~ inform him rapidly about the subject so that he is subsequently ~~ad~~ able to frame more specific questions he has not suffered from an overly coarse index. However, when he is able to pose question which are specific enough that they are limited in translation into the index language by the latter's coarse structure, the nature of the file material and its ability to provide clues for ~~its own~~ the searching of itself will determine ~~his~~ the progress of his search.

"Team Research"

Report of D. B. Hertz & A. H. Rubenstein – discussion of methodology for assessing informational needs of scientists.
(out of print)
Eastern Technical Publications, New York 1953, 103pp.

80% of 25 top-earning cos. – scientific employees spent 6–15% of the time with literature.

O.R. program in US on info uses & habits?
(Ackoff at CIT) role of info in the research process & way in which scientists locate & use info

Notes on: Methods by Which Research Workers Find Info
ICSI p153 (Area I) Fishenden.

User needs — (1) current literature
(2) for retrieval

Aug 22, 1961

suspect that not a great deal of importance is placed on completeness of info search.

only 3% use of foreign literature — cost of this omission.

reading split ½ & ½ between background & use

slight use of reviews — perhaps because nuclear field is new

4.3 reading acts per wk
5.8 " " " reported by Shaw.

Habits of junior & senior staff members very much alike

"Pure" researchers use journal literature preponderantly
"Applied" " " reports & abstracts as well as lib services

Interview results corresponded well with diary cards as far as use of info bulletin, library reports & Nuclear Science Abstracts is concerned.

IC 51
Anal p 87.

"An O.R. Study of the Dissemination of Scientific Info."
M.H. Halbert & R.L. Ackoff.

3 aspects of scientific communication studied: (1) production
This concentrated on (2) dissemination
(3) consumption

Time available for scientific research was taken as a measure of scientific productivity but no relationship was assumed.

3 questions tackled

(1) How do scientists actually spend their time?
(2) In what types of scientific activity are there the greatest potentialities for reducing time expended without cutting scientific output?
(3) How can these reductions be realized in the most effective way?

Classifications Used for Scientists' Time

	Mean Values		Mean values
Scientific comm x	33	Data treatment	6
Non-sci bus comm x	10	Personal & social	10
Thinking or planning alone	6	None of these	4.4
Equipt set-up or maintenance	6	Out of area	
Equipt use	23		

within Sci Commx a further breakdown used (Chemists)

(a) By phase

1. Hearing question
2. Reading question
3. Reading for use
4. Reading for gen. info
5. Hearing info
6. Working out material (understanding)
7. Editing material received
8. Writing info
9. Telling info
10. Writing question
11. Asking question
12. General discussion
13. Discussion about received commx
14. Reading for retransmittal
15. None of these.

(b) by type of person involved

(c) by channel used

1. oral
2. unpublished written
3. book
4. Article
5. Abstract or review
6. None of these

Data was collected by observing the chemists at work at random intervals – little consultation with scientist needed.

% Scientific commx time allocation

	Avg
Total	33.4
Gen Discussion	10.3
Oral non-discussion	9.2
Total	
Written	14.3
Unpub written	9.5
Pub. written	4.9
Sending, oral	4.5
Receiving, oral	3.8
Sending written	5.0
Receiving, written	7.2
Retransmittal	2.7
Reading articles	2.6
Reading for use	3.9
Reading for gen info	3.2
Commx ē other sci (nonchannels)	2.7
Commx ē other company personnel	7.1
Commx ē channels	21.4

Sending - receiving as written-oral %

	Sending	Receiving	Total
Written	5.0	7.2	12.2
Oral	4.5	3.8	8.3
Total	9.5	11.0	20.5

 ICSI p.71 Aug 23.

Determining Requirements for Atomic Energy Info From Reference Questions - Herner & Herner.

Thoughts that come to mind as I read this:

- (1) Only some informational needs will be mirrored in questions to librarians
- (2). These will often be in the form of requests for articles & books instead of for information.
- (3). All the informational needs that are satisfied by going to other sources than libraries will not appear from the questions to librarians.
- (4) There will appear only needs that can easily be put in a form that allows their satisfaction to be delegated to others.

Only 2.9% of the questions had to do with radiation effects - far fewer than one might suspect would be the case

As the abilities of mechanical info retrieval systems increase must consider the question the seeker puts rather than the way - abstract journal, library list, etc. - he uses now to get to his article rather than to the info he wants

Searches on several concepts are more difficult to make but multiple concept questions do ~~occur~~ get ~~for~~ asked by seekers

Aug 23

In seekers questions (3851 in number) distribution of concepts is as below

	1	2	3	4	5	6
No. of concepts	1	2	3	4	5	6
No. of questions	466	1818	1167	327	73	0
Per cent question	12.1	47.2	30.3	8.5	1.9	0

Logical relationship of these questions was as follows

	Logical Products (A or B)	Logical Sum (A & B)	Logical Diff (A & $\bar{B}$)
No. of questions (> more than 1 quest)	3773	45	3
%	98.0	1.2	0.8

100.

Most of (77%) the questions (non-technical) fall in the 1st 3 categories.

For technical questions the spread across the questions was more uniform

Aug 23, 1961

Retrieval Questions from the Use of Linde's Indexing & Retrieval System, ICSI, F. R Whaley Area 4 p101.

To realize maximum advantage of the system (indexing of Linde Cos. reports), experience is needed in asking questions of a depth or specificity previously impractical in a conventional system.

Aug 24 '61

An Over-all Concept of Scientific Documentation Systems & Their Design - ICSI Area 5 p 1048 Crane & Bernier

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Mis communication - inserted, lack, over, concealed.
Commx - religious, scientific, technical, misprational.

Major Difficulties

1. Too few or too many reference terms
   - for discovery must expect non specific response
   - for recall desire specific document.

2. Blank Sorts resulting from searches for non existent classes
   - many logical combinations of terms will correspond with no documents
   - should find out about such a class ~~soon~~ early in the search process & be able to distinguish between it and imperceptible loss of info.
3. False drops - irrelevant info
4. Confusion of meaning because relation among vocab many terms.
5. Deficiency in effective & immediate suggestion of closely related and substitute information.
6. Necessity for manipulating the system before relevant

Aug 25, 1961

documents can be located.

7. The relative bulkiness of the recording media etc when compared with indices in book form.
8. Costliness of manipulative systems makes them unattractive in the light of their bulkiness
9. Delays caused by need to manipulate the system – For many searches non-manipulative systems would be more rapid.
10. High cost of storage or access to it limits the number of users & so restricts communication leading to misscommunication of the "lack" type.
11. Concordance of vocabularies of searcher & selector. Failure may result in many blank searches.
12. Facilitation of generic searches.

The Analogy between Mechanical Translation & Library Retrieval. ICSI Areas p 918 Aug 25 '61

Propose a conceptually based thesaurus type of language classification to be used for a completely generalized retrieval procedure, this classification procedure being by nature interlingual.
(Linguists claim this will only translate on a semantic not a linguistic basis)

A distinguishing feature about a thesaurus is that it has the mathematical form of a lattice rather than of a tree. It consists of a set of headings under which are grouped synonomons words, phrases, or sentences. It also contains a cross reference between words and headings. The thesaurus is essentially interlingual in that the headings have synonyms in any language.

Aug 28 1961

The Thesaurus Approach to Information Retrieval
American Documentation, July, 1958, T. Joyce & RM Needham

Refers to article by Vannevar Bush (1945) as the starting point of mechanical information retrieval - points out the deficiencies of our present classification systems.

Classical approach to retrieval systems

1. Documents to be added to the system are processed so that info. about them is retained to assist in their retrieval.
2. Requests for information are processed in a similar manner.
3. Data about the documents has & compared against it information on the request so that relevant documents may be selected.
4. Access made to the relevant document.

Two broad approaches to the 1st step.

a. Classifying - Dewey or Bliss system, possibly c physical segregation. The difficulty is: (1) in choosing the right category, and (2) in having duplicates to put in each appropriate class.

(c) Indexing the documents by selecting the terms, descriptors etc. that sufficiently describe the subject matter to ensure proper retrieval.

The two difficulties of multiple aspect indexing are:

(1). choice of terms is difficult — too great generosity will yield too many "false drops later". If the subject analysis is uncomplete a loss of information may later result.

(2) lack of structural relation ~~between~~ among indexed terms may result in "false drops".

The Thesaurus Approach.

Problems of synonymity arise with a large number of terms that do not come up ~~c~~ few. The thesaurus idea is advanced to capture the advantages of both systems that employ a large and a small number of terms for indexing.

Simple thesaurus approach

1. A number of head-words (thesaurus headings) is prepared and put in ~~a~~betical order

2. Each document has punched on its card a

hole corresponding to the head words under which it falls

3. Requests are translated into head-words and then cards for each such word are used to as a mask for each card in succession in the document file.

4. All matching cards are used to retrieve presumably relevant documents.

Luhn (IBM) has proposed a mechanized version of this.

CLRU Approach. (Put foward in 3 papers at MIT in 1956)

Language is regarded as consisting of words which necessarily derive their significance from the context. This is in opposition to the view that words have precise meanings, some words unfortunately having several.

It was first decided to preserve, as units of the system, the key terms used in any document, thus retaining the the advantages of such a system as Uniterm.

∴ A term abstract was made of all documents and this was used as the starting vocab.

This vocab. was then arranged in so that the property of

accommodating near-synonyms held at all levels.

If you ask for A, you musn't complain if you get $B' = A \geqslant B$

The documents are represented by holes in punched cards which represent the various terms, and in addition, when a hole is punched in any term card, all the cards representing terms at higher levels of the lattice, such that the inclusion relation holds between them, are punched. This requires a cross referarence among the terms.

Development of a Technical Thesaurus. Aug. 28, 1961

The language problem in information retrieval

1. Viewpoint
2. Generics
3. Semantics
(4) Sytax.

Definitions

Vocab. control – a method of anticipating and providing solutions to the communication and language problems inherent in viewpoint, generic, & semantic considerations.

Vocabulary – the list of terms used in the thesaurus.

Technical thesaurus – the bound volume which is the physical form of vocab. control methods employed for the information system. The thesaurus employs "related terms", "see references", and "generic posting" to solve the viewpoint, semantic and generic problems.

Solutions to the language problem. (two possible

→ 1st a language can be prescribed for storage and for retrieval

Examples: Dewey decimal system, Library of Congress Index, U.D.C, etc.

Comment: Prescribed indices are characteristic of data (low order of abstraction) rather than information (high order of abstraction) retrieval systems

→ 2nd Redundancy may be used in the retrieval of information

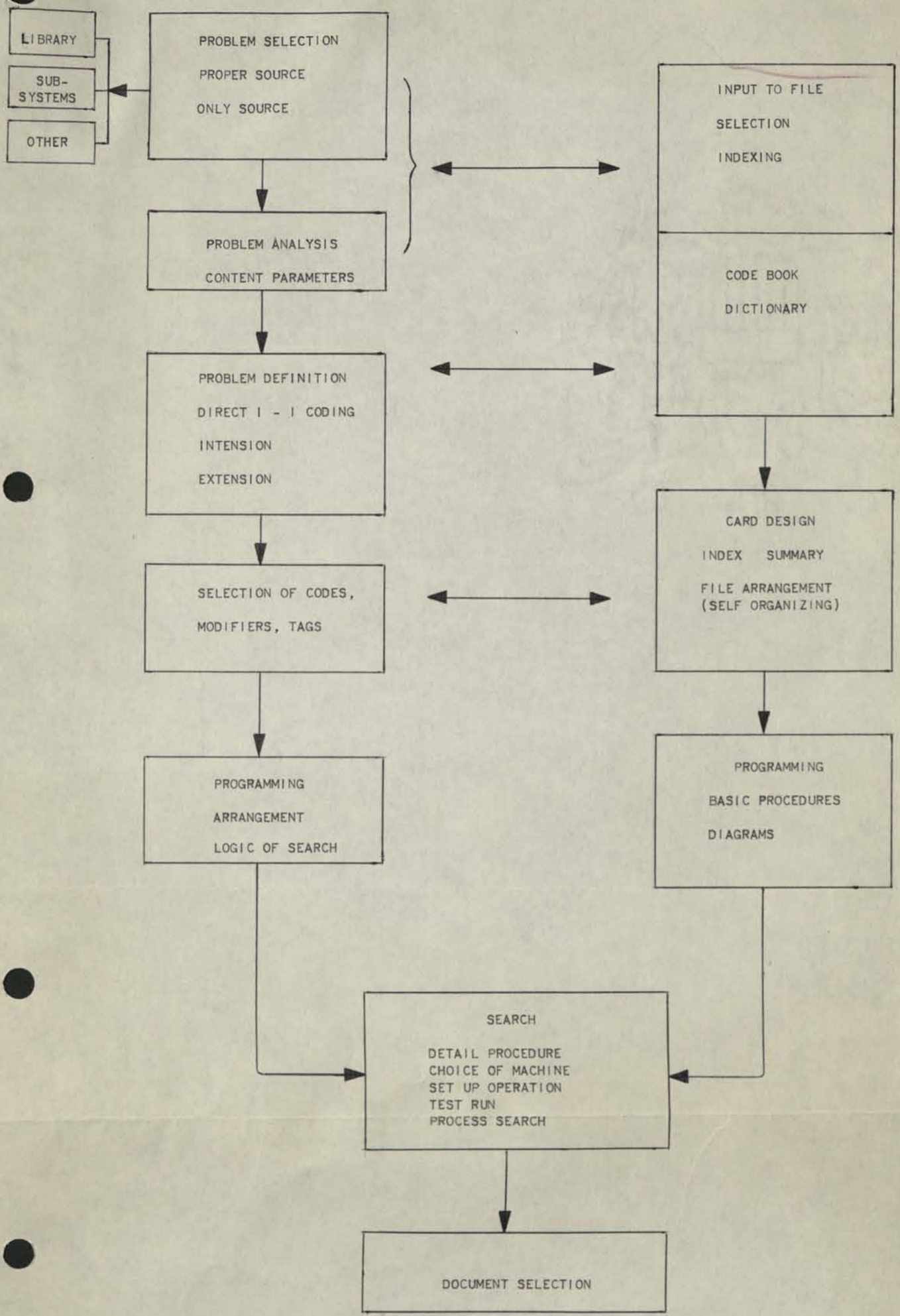
Redundancy can be used both in indexing and in searching. The choice of the one to use is purely one of economics. A technical thesaurus makes possible either redundant indexing or searching with the degree controllable to the situation.

Creation of a technical thesaurus is made easier by the fact that in each scientific field there exist only about 5000 nonsynonymous words, 20,000 covering all fields.

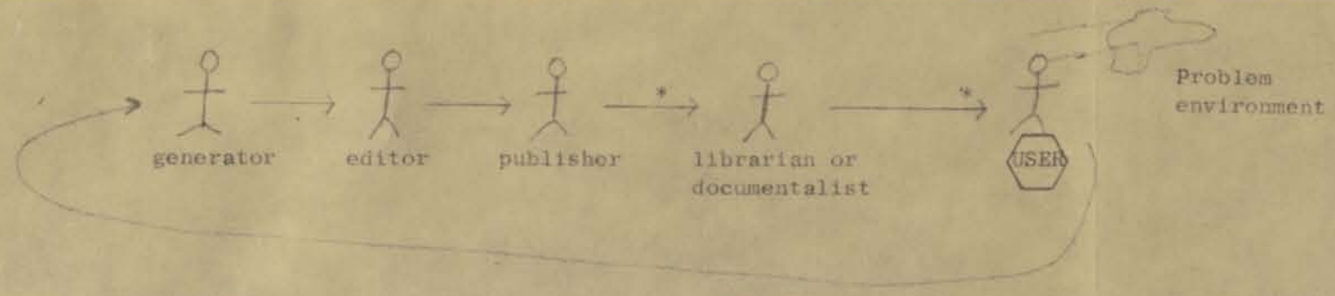
From Paul Howerton

SYSTEM DIAGRAM

RELATIONSHIPS OF RECOVERY TO INPUT AND MACHINES

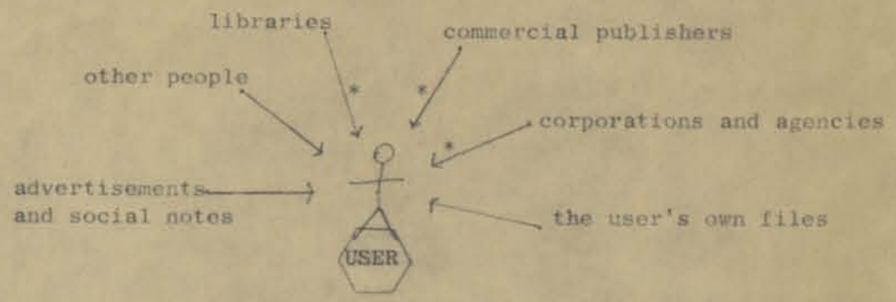


1. CHAIN



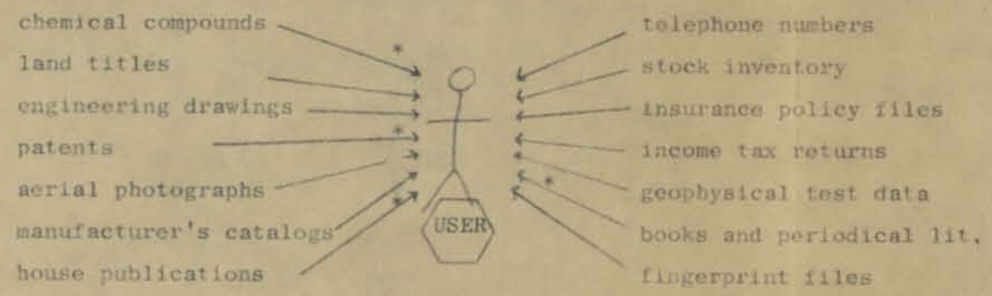
Viewpoint: What links in the chain of operations can be considered as being in the field of documentation?

2. INFORMATION CHANNELS



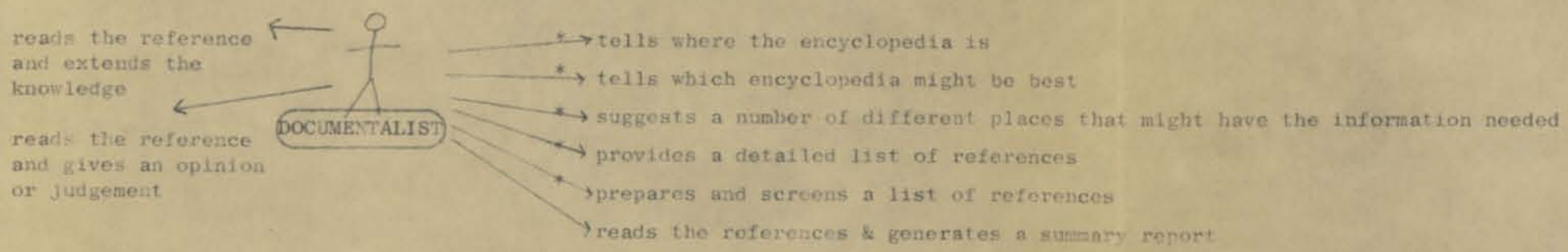
Viewpoint: What channels of the user's information sources are considered as being in the field of documentation?

3. TYPE OF INFORMATION

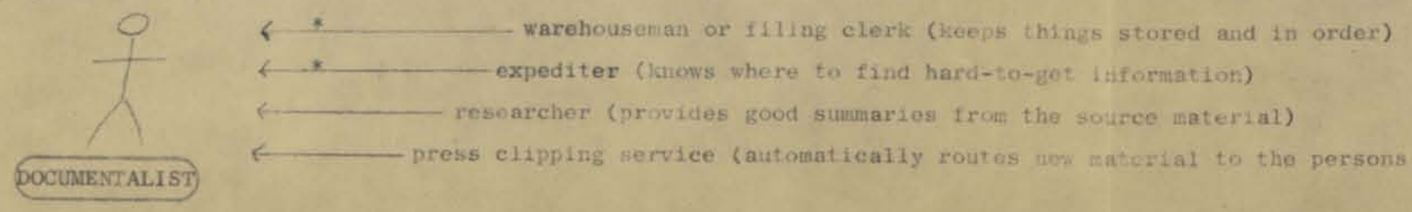


Viewpoint: What type and complexity of information might be handled by documentalists?

4. DEGREE OF INVOLVEMENT WITH THE USER'S PROBLEM



5. HOW THE DOCUMENTALIST APPEARS TO THE USERS



NOTE: The arrows with asterisks are the items which are generally considered (today) to be in the field of documentation.

SEVERAL VIEWS OF THE FIELD OF DOCUMENTATION

ACQUISITION

39,490 abstracts

1000 journals + reports

($9500. subscription value)

($3000 worth/yr. published free from another library)

(1 full time clerk to handle acquisition + routing)

→ photocopy for parallel routing; retain film copy for later making throw-away prints.

(3/4 clerk)

ABSTRACTING

purpose abstracts

EDITING + Q.C.

LIAISON

fringe = 4% / payroll

O.H. = 15% of the total

EQUIP. & SUPPLIES

Rankin bristle file cabinet

3M Microfilm viewer-printer (13 cents/page with cost to make prints)

Verifax book copier (11 cents/pg in materials if transparent film is made on Verifax + printed on Brueing)

~~photocopy machine~~

Brueing Copyflex (16.2 cents/page material cost for transparent film average 10 abstracts/page; Brueing copy sheets 5×8 = ½ cent)

film envelope – 1 cent each

file cabinet

typewriter

paper supplies – dividers, clips, etc. – $160/yr.

all equip. amortized over 3 years.

4 Typewriters

3 file cabinets

numbering machine

forms – 4 cents each

Intellectual Model of the Search Process

How to allocate your resources (choice of libraries + procedures)

Value as penalties for redundant + irrelevant info.

incremental values for increasing amounts of info (diminishing returns?) value proportional to total No. items provided

penalty for missed info.

shadow vs deep indexing

Speech & delays

1. Decreasing worth of information as it is provided - but it may cost more to provide this extra increment.
2. Some searches require a single answer (e.g. specific melting point) - Any info besides this 1 item is educational but has no value to the searcher.

System capability to reject incoherent or ambiguous questions?

Do you ~~drag~~ penalize the system for not telling you (after analysis) that there wasn't any information on that search topic?

Different values for different pieces of information