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AUTHOR Hall, Homer J.
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ABSTRACT

The value systems by which the users of purchased information services select which one to use or buy are found to differ sharply among different user populations, but the variable found to control them is a function of use, not of the user as an individual. Selection variables are summarized in a matrix of user values and interaction effects. The researcher prefers original documents, and tends to choose subjectively. The operating manager more often stops with abstracts and emphasizes quantifiable factors. The planning manager wants a digest of ideas, not references, and tends to judge a service first as to its reliability. These three functions attach entirely different connotations to the same words for key parameters. They can be linked to the structure of language: operations is the present participle (doing), research concerns the verbal adjective (state of the art), and planning is in the subjunctive mode (could or should). Apparent conflicts, which may be resolved by dimensional analysis of difference in values perceived, are illustrated by case histories, interviews, and questionnaire results. (Author)

USER VALUES IN THE SELECTION OF INFORMATION SERVICES

FINAL REPORT

on

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by

Homer J. Hall

Exxon Research and Engineering Company
Government Research Laboratories
P.O. Box 8
Linden, New Jersey 07036

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FOREWORD

This is a first-year report of research on improvements in the use of scientific and technical information (STI) supported by the Division of Science Information (DSI), National Science Foundation. It provides a systematic investigation of criteria applied in decision-making by a wide variety of individuals who are users or managers of purchased information services in the commercial sector of the information industry. DSI is interested in criteria for the comparative evaluation of information services, including variables that influence cost and those that do not. We are supporting research on methods to measure the value of these services, as part of our overall program to improve the efficiency and effectiveness of the utilization of STI.

Your suggestions and comments on this report will be appreciated.

Lee G. Burchinal
Director
Division of Science Information

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USER VALUES IN THE SELECTION OF INFORMATION SERVICES

HIGHLIGHTS

Which information service to use, and why? Users' preferences among services and their variations from time to time are analyzed in this study for the User Requirements Section of NSF. The controlling variable was found to be the function for which processed information is desired: for research (how to do things), for planning (what to do), or for information operations (doing things with the information itself). User populations which differ in their values for purchased services can be grouped according to this use function. The services considered were categorized as access tools for direct use, or paid searching, or information analysis and evaluation.

The principal finding of this study is that the value system which a given user applies in selecting an information service varies from time to time, depending upon use as an event rather than the user as an individual. There is a subtle but distinct difference from the initial proposal for this study, which was to identify groups of users who agree and disagree and to explore the characteristic patterns of use by which they might be distinguished. The identifying variable is useful to a vast variety of users: a given person may be acting as a scientist today, a searcher tomorrow, and a planner the next afternoon, and the service he prefers will depend upon his function at the moment. This functional relationship may explain why previous user studies tend to gloss over the behavior of the individual as being an erratic and unpredictable unknown.

Each group of users has its own set of priorities and special connotations for variables in the selection process. Workers involved in the research/development function (scientist, engineer or patent attorney) place high value on subjective factors of service quality or convenience. Those involved in information operations (searching or retrieval) are more concerned with the quantifiable factors of time, cost, and facilities available. Planning (management, staff, or individual) is more judgmental, and seeks an individual whose purchased service can be trusted before even considering factors of cost or convenience. Managers or users of information services whose function at the moment is research or operations or planning may attach quite different connotations to the same key words, such as useful information, pertinence vs. relevance, depth vs. breadth, timeliness, time, and costs. The result is a conflict in value systems which is often unrecognized.

This basic finding and its implications were developed by direct interviews with some 60 individuals. The technique applied was a dimensional analysis of the factors in the selection process which each user considers most important. Selection factors can be grouped in three dimensions as quantifiable, qualitative, and judgmental: these are all recognized as important by all user groups, but with sharp differences in the relative values they perceive. The emphasis on the individual was a direct opposite of what some people prefer when they use the "Delphi approach" and mask all personal differences in anonymity, to arrive at a statistical consensus. Lists of discriminant factors were first prepared in

interviews with specialists who spend over 50% of their time in information research, and expanded to include users who are scientists, engineers, attorneys, and planning staff. Each of these populations included four to six individuals in the basic group of 30 interviews in-house. Preliminary conclusions were augmented and confirmed by interviews with an equal number of users and managers of information services in other companies. These drew special attention to the experiential and intuitive components in management judgment, as distinct from the quantifiable/rational and qualitative/subjective components in conventional evaluations of cost effectiveness and cost/benefits.

A Matrix diagram is proposed to summarize the diverse effects of many factors and interactions in the user's selection process. The major variables are entered in matrix rows: selection factors, user populations, and types of information service. Sub-element dimensions are expanded in separate charts. The columns in the matrix represent how these variables are defined by function, how they are perceived by the user, and how they interact. One interaction effect is the difference in priorities of different user groups. Other interactions involve the environment of the use-event: user concerns, management concerns, and maturity of the project.

A questionnaire was developed at the end of the study to examine the acceptability of the parameters selected and the definitions proposed for them. This was addressed to 89 individuals who consider themselves as users of information services, out of a random sample of 240 professional employees at Exxon. A preliminary analysis of the returns shows significant differences between the statistics for research scientists and for engineers. Only a third of the engineers had used the published literature to search for information during the year 1975-76, vs. nearly half of the scientists. Scientists tend to value the the published information more, and they gave a much higher response to the questionnaire. They used or specified more services by title during the year and requested many more searches. Perceived values were strongly positive for scientists and negative for engineers, in preferring original documents versus abstracts, requesting the use of a specific service, or asking a known individual to collect the information. This preference for a known person was even stronger for searches ordered by patent attorneys, who cited it as their primary basis for selecting a service. All users agreed that they want to get key references promptly before a further search, and there was a strong vote against expecting the customer who gets the information to know how to use a computerized system. It must be recognized that these replies were in an environment where information services are tailor-made to company interests, and available on request.

Case histories developed during the study have shown that this approach can defuse many areas of potential conflict. The junior staff employee need not feel that a management change in his recommendations implies a criticism or lack of confidence; a new business which is small still needs both a broad view of information for corporate planning and specific details for R&D; the information specialist in a small library may be valued most for non-computerizable skills in upgrading the input to the system, not as a paid searcher. It was possible in each of these cases to detect points of view which could be easily recognized by parties who had been in disagreement, as different but not opposites. Accepting these as a valid basis for joint action avoided the destructive effects of a forced choice between them.

EXECUTIVE SUMMARY

Improvements in the dissemination and use of scientific and technical information have created a growth industry of competing information services whose survival depends upon users and customers. Users differ, and the value systems by which they decide which service to select at a given time are a complex function of identifiable variables and relationships. The present study has been conducted for the User Requirements section of the NSF* to explore two questions: who wants to use what services, and how does the user decide?

Different groups of users are found to differ sharply in the priorities they assign to major variables in the selection process. A primary goal of this study is to help each user to identify his or her own patterns of use. Related goals are to explore weaknesses in the user's methods of selection and where to look for help, to recognize others whose points of view are similar or different, and to benefit more readily from shared experience as a result. This is an analysis of controlling variables from the viewpoint of the user, as distinct from that of the designers or vendors of services who have contributed most of the literature on the subject. Field of coverage is an important variable but it is excluded from this study by definition, since if there is only one service in a given field there is no competition.

The selection between services is seen as a dynamic process, in which each user can assign his (her) own values to the factors involved. These value judgments can change for the same person for each use event, depending on the environment of use, the type of service, and the function for which the information is desired. It is necessary for this discussion to give clear and arbitrary definitions to a set of basic terms:

STI - the whole gamut of recorded scientific and technical information, and associated access tools.

Purchased information service - a commercial enterprise providing its users and customers with processed information, which saves them from having to get it from original sources.

User - the one who selects which information service to buy or use and works directly with the service selected, so choice is based on personal experience.

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Customer - the one who pays for the information supplied, directly or indirectly, but may not have any part in the use of the service or in the selection process.

User population - an identifiable group of users who have the same basic needs and values for information services. The difference lies in what function the user is exercising at a given time: the same individual may be functioning as a scientist today, a searcher tomorrow, and a planner the next afternoon.

User populations and some of their characteristic similarities and differences have been examined in this study by interviews with 60 known users or managers of information services, half of them within ER&E and half outside. This included a strong program of field discussions and conferences during formative stages, to test and refine the preliminary results. Conclusions drawn on this basis were then checked by questionnaire, based on a 240-name random sample of professional employees at ER&E who are potential users of purchased services.

A Matrix diagram is shown which summarizes the differences observed in user values and their interaction effects. The major variables for analysis are presented in the matrix rows, as selection factors, user populations, and types of information service. The matrix columns represent how these variables are defined, how they are perceived by the user, and how they interact.

There are many discriminant factors which can be considered significant in the selection process. Initial interviews suggested that these can all be categorized as quantifiable, qualitative, or judgmental. Variables in each of these dimensions are so linked that they tend to move together in any change or comparison. For example, data on cost, time, physical facilities, or personnel can be considered as one such group, in the dimension of quantifiable factors. That is to say, any circumstance which has a major effect on cost, time, facilities, or staff requirements is likely to have some effect on other variables in the same group. This concept of dimensions in evaluation is taken from earlier studies on the value of research projects.

A second dimension which is well recognized includes the whole gamut of qualitative factors that cannot be measured exactly but which can be handled by the technique of subjective ranking. The exact names given to such information service concepts as convenience, flexibility or responsiveness are hard to define, but they tend to be interrelated and move together when any one of them is significantly changed.

The decision process also involves factors of judgment which can have a yes/no answer. Judgment is a function of management, and the manager may be the same person as the user or someone else. The judgmental dimension is hard to argue with, based on neither numerical facts nor subjective rankings alone but a "common sense" blend of these with intuition, based on experience. Reputation, suitability or future prospects often involve a major contribution from the judgment of other managers. Outside of management these factors are often deferred to others and then taken for granted.

MATRIX OF USER VALUES AND INTERACTIONS

Parameters	Variables* Defined as	Perceived Values
Selection-Factor Dimensions		
Quantifiable	Budget/costs	Rational
Qualitative	Convenience	Subjective
Judgmental	Reputation	Intuitive
User Populations		
Scientist, engineer, attorney	R/D function	Wants Originals
Searcher, information analyst	Info operations	Abstracts abs + orig
Manager	Planning function	Evaluation
Purchased Information Services		
Access tools	Self-service	Impersonal
Searching	Pre-defined questions	Intermediary
Analysis	Optimized during search	Highly individual

Interaction Effects

Users' Priorities

Environment of use
User-worker concerns
Management concerns
Maturity of project

* Variables as listed are typical, not all-inclusive

The specific factors listed are typical of many others. The important point is that dimensions in the selection process can be recognized, regardless of the exact names associated with them, and that they can be used to characterize parts of the selection process. The dimensional approach has the advantage that the categories named are complementary, not opposites, and therefore less likely to leave holes in the matrix.

The literature on the relative importance of user-selection factors is biased at this point, since it depends largely on who wrote what. Articles which emphasize the importance of cost tend to be written by vendors, including in-house managers, who have a service to sell. Both are continually asking in the literature for cost data from others to compare with their own. Other authors examine cost/benefit relationships that include subjective factors. This viewpoint is characteristic of the social scientist. The judgmental approach is commonly recognized in journals of industrial management but it can be anathema to the "purely rational person" who prefers budget numbers and considers even cost/benefit ratios as a compromise. These strong differences in priorities and points of view tend to confirm the validity of using the dimensions chosen, as separate factors in the decision process. This is not to say that any one user of services will base his choice entirely on one set of values -- all of them are important. What it does say is that while the same variables apply to all users, they are differently perceived.

User Populations

The central feature of the matrix comprises three groups of user populations which can be distinguished by function and how they use the information supplied. This distinction is shown by whether the information they most want to have "hands-on" is original documents, selected abstracts and references, or evaluated overviews. First is the research function which includes scientists, engineers, and patent attorneys, professional men whose information need is, for original documents, but for different reasons. The scientist wants to study and compare different sets of original data, or the methods by which they were obtained. The engineer wants a single set of reliable data and the conditions held constant to obtain them, but not all the data there are. The attorney drafting a patent or a new agreement needs the complete and exact wording of selected originals, but is less concerned about data.

The information operation of searching (or the individual who is acting as a paid searcher and not as a scientist or as a manager) is frequently satisfied to stop with an abstract or reference by title only. This identifies useful source documents and where to find them, but does not require their physical production.

Planning as a function of management may be delegated more or less completely to planning staff or to others. Planning prefers an overview or information digest, for the selection of target areas. Typically pressed for time, the planner wants immediate access to all available viewpoints and suggestions on how to evaluate them, to decide which ones to pursue. He is looking for ideas and is less concerned at the moment with originals, or where to find them.

Priorities

The simplistic statement for any user who has a choice is that he wants "the best service he can afford, for a given use." This difference in function depends upon the specific use event, rather than emphasizing the variable needs of a given individual. Interviews with users in different populations suggested completely different priorities in these relationships:

- The research scientist/engineer chooses first of all the service he finds most convenient to use. He accepts the judgment of a manager as to what systems to consider, but he pays little attention to the quantifiable factors of cost, time, or facilities as long as the systems available give him the answers he needs.

- The planning staff or manager makes a first choice on whether the service in question is reliable and "suits our way of doing things." He has to consider budgets on all the quantifiable factors, but may include qualitative factors only after he has ruled out services which he finds unreliable or too expensive.

- The literature on information operations emphasizes cost, time, and all the quantifiable factors a vendor must control to keep his customers. Qualitative factors may be recognized in cost/benefit studies, but somewhat grudgingly because they cannot be accurately measured. Judgment as a separate dimension is not so clearly recognized in the literature on information services as it is in discussions on business management.

It must be emphasized that these "priorities" are all relative values, not absolute. Cost data, for example, appear to be less significant to the scientist than convenience or reliability: this is not to say that cost data can be ignored, but only that the scientist is more likely than the vendor or manager to put other factors ahead of cost.

Purchased services from which any user may select fall into three major categories:

- access tools for direct use, at all levels of complexity. These include indexes, abstracting services, and computer data bases in routine use.

- a purchased service that does searching for known facts, where the question is defined before the search begins;

- a service for information analysis, where the user pays someone else both to find and to analyze the information available.

The same information services, even the most sophisticated ones, may be used for self-help, for paid searching, or for information analysis: the difference lies in the user, and how the information tools and services are applied. In general, the information analyst is applying a higher level of skills than in searching alone, because the analyst must understand the technical language of the literature and the customer's needs, as well as the inner workings of the searching procedures used.

Environment of the Use-Event

Interactions with the environment of user concerns, management concerns, and specific project are an active part of the selection process, where the three types of service defined differ significantly in their effects. The routine use of an index or abstracting service is perceived as impersonal and for this the user/worker will accept any competent assistance. The user who is buying a literature search is more concerned, to be sure that the intermediary employed understands the points agreed upon in negotiating the question. The user who has asked for information analysis paying someone to think for him. This is a highly individual matter involving the user's self-esteem, and he wants to know exactly who the analyst is.

Personal impacts are high in a situation where the user feels that he is applying his highest skills. This interacts with user function: research is concerned with finding gaps or inconsistencies; the searcher is concerned with completing the reference file; the planner may consider one of his essential tasks as browsing in selected sources to find useful results from another field. In whatever area each user considers critical he is likely to insist on the services of a person he feels he can trust, or he may reject any such help as undesirable interference and do this part of the work himself.

Other impacts of the environment include both limitations on the user and positive effects. A guiding principle here is Mooer's law, which says that the user of information tends to avoid any action which gives him pain. For example, freedom of choice can be sharply restricted by limited authority for cost approvals. Within the user's limits of approval, the "free vs. fee" argument may impose a forced cost decision on users whose value system would always place convenience or quality first. Their skills in the budget/cost area may be so poor that a forced choice is arbitrary or capricious, ignoring cost/benefit trade-offs which they normally defer to someone else. Conversely, utilization may be improved by setting up for the user clearly defined blocks of services for which approval for him is free, or easy to get, or more difficult for special situations.

Another user concern is the capability of the individual to use the information supplied. This is not the same thing as knowing how to use the service, nor does it mean that he is actually going to use it. It helps to avoid overkill or answering the wrong question. Information

can be tested out in many ways, say by computer modelling or by discussion. The point is that the selection and use of information is easiest and most effective in areas within the user's experience. Personal interest and self-esteem may lead the user to invent reasons for trying the newest and most sophisticated techniques, as part of the learning process. Values in such a case accrue in actual use, not potential use, as witnessed by the experience of firms who overbought on computers as a status symbol.

In an information operation where performance standards are maintained, accuracy and completeness may be taken for granted. This is not always true, and where it is not these parameters quickly become vital. Vulnerability to poor data or negative information varies with the specific use: it is high for a quick answer taken at face value. Even unreliable results which are properly reported may be valuable in research for detecting a result which seems out of line. This can be a nuisance in searching and even more so in planning, unless the uncertainty itself is important. A definite lack of concern for the scientific quality of information applies to certain operations of the planner surveying a new field, who wants the widest variety of points of view available. He is not necessarily concerned with whether a new viewpoint comes from a scientist or a tabloid columnist. The tabloid bias may be just as important to him, if he wants to examine this bias and use it in planning his own work.

Management concerns are a major element in determining the environment of use. Choices in this area are a matter of individual style, as much as company policy: the manager who values the information approach allows extra time for it where the manager who is unsympathetic may not. There are other such concerns which apply to information as a whole, as well as to the use of purchased services as one means of obtaining it:

- are individual efforts and team work both encouraged?
- is innovation desirable or a threat to established lines?
- is a quick answer or no answer an acceptable response?
- is any premium allowed for quality of information?
- are benefits realized in this project expected to help support other information services, or vice versa?

The maturity of the specific project bears directly on how much information is needed and what type of service will supply it. Breadth of coverage, detail, and when to stop are interactive decisions which apply at all stages of urgency and justifiable expense. Basic research, patenting, and market development may all benefit from a state of the art review. A novelty search is more specific, once a project has been defined. Project negotiations or contracts must define and clarify those aspects of the new development that someone is willing to pay for. The over-riding question of liability has grown far beyond the caveats of business law, in response to government demands by such agencies as the EPA and FDA. Complete evaluation, best available technology, and environmental impact statements represent a significant part of the present total demand for information services.

Interviews and Questionnaires

Initial interviews with the major users of information services confirmed the concept of dimensions in selection factors, and identifiable user populations as a reason for differences in the values they perceive. Further interviews to identify additional variables and their interactions surveyed the pattern of selection for specific populations of information searchers, patent attorneys, a university library, and the users of a small branch library.

A more detailed questionnaire was developed to explore the characteristics of the user populations identified, and improve the definition of acceptable terms. This was designed as an opinion survey for use in hand, with written definitions, to decrease the effects of the variable bias of the investigator during interviews. It was addressed to a random sample of 240 named individuals picked from the professional employees at ER&E. In this sample 130 individuals were located at the engineering research center, 90 in laboratory research and 20 in smaller groups such as information specialists or patents. These sub-sets represent 10-20% of the employees sampled. The list was then checked or a telephone call was made to ask: have you during the past full year (1975-1976) done any searching in the published literature apart from reading current journals, either yourself or by asking someone else to conduct a search for you? A questionnaire for this survey was sent to a total of 89 who were known as users or who thus identified themselves. This 4-page form took an average of 15 minutes to respond.

The initial query showed that 49 of the 130 engineers use available literature services to search for information versus 81 who search only in company sources or current journals. This ratio is nearly 1 to 2 and the same ratio for research was 40 to 50 or near 1 to 1. The greater interest of the researchers in information services is reflected in responses received, which was 38 out of 40 from research versus 32 out of 49 from engineering. Similar trends appear in the average number of searches made during the year, which was about 2 for the engineers and over 4 for research. The same applies to familiarity with different information services; a check list by title of those used at least once during this period showed an average of one for the engineers, and three or more for research.

Values perceived by these two groups were ranked on a 5-point scale (vital, yes, neutral, not needed and prefer not). The weighted average was strongly positive for research and negative for engineers on the use of originals versus abstracts, using known services, and asking a known individual to collect the information. Both groups agreed (90 vs. 80%) that it is important to get key references promptly, before any further search. Both ranked completeness in a search ahead of accuracy, the engineers a little more so. The strongest agreement was on two questions with heavily negative response and 10-20% of the total as "prefer not," for the importance of knowing exact dollar costs to compare services and for the user/customer himself to know how to use computerized information systems.

These replies are in an environment where information services are available upon request and an abstract service tailor-made to company interest is distributed to all employees. Without this bias, it is felt that the ratio for originals vs. abstracts would be even stronger for research. Different rankings might also be expected on some factors, e.g., on accuracy vs. completness. Further inspection in this particular sample showed that the only engineers who preferred originals were 3 men out of 33 respondees who had come into engineering from a background in research.

Conflict in Meanings of Key Words

A major conclusion of this study is the completely different connotations which different groups of users attach to the same key words. A functional approach to this semantic problem is shown in Table 6.

Timeliness of information has a special meaning for R/D, namely, information produced at the right time - neither too early nor too late. This may create special values for a redundant service which can produce pertinent information recently current, but not yet adequately covered in the comprehensive abstract/index systems.

The manager of R/D makes a basic choice as to the amount of time he will allow for the use of information, frequently about 10-20% of total project time, as distinct from going out in the laboratory or the field to get more data. The choice is labor-intensive, depending on competing values for the worker's time. It may be changed little if any by a high-powered new service which produces more information in less time but requires more time for proper analysis. There is a strong consensus that the time devoted to more effective services is essentially subtracted from less effective sources of information.

Priorities in selection for research are addressed to details in pertinent references, having a clear stress on a definite concept or request. The search can stop when you get the answer, or new targets may be defined. Dependable quality as a resource material is a primary concern. Costs and cost/benefits are applied separately to each project.

Work flow to keep the information system operating uses 100% of the time available, for the workers and managers concerned. This is split between routine operations and output. The operation is labor-intensive, with a strong component of indirect costs to maintain the system.

Timeliness for operations is measured in terms of prestated time schedules to get new items out, and how dependable this production schedule is for the user. The schedule times which are frequently most important to the user are the earliest date when he might get the information, and the latest date to which this may slip when things go wrong. These can be much more significant than the average time, which the operators of the system might prefer as a measure of performance.

Table 6

Conflict in Sets of Meanings for the Same Key Words

Parameters of Value to the User	Connotations for Different Functions of Use		
	for R/D Function	for Information Operations	for Planning Function
Useful information	how to do things, or what not to do; knowledge	accessible output; work flow, doing	target selection, what to do; insight
Specificity	pertinent to specific target	cover all good sources	relevant to target areas
"Hands-on" access	all pertinent originals	abstracts and references	digest of points of view
Depth vs breadth	details, on selected items	breadth of coverage	breadth of view, not details
Timeliness	not too early, not too late	at the time promised	immediately, on demand
Total time allowed	10-20% (info. vs lab)	100% (routine + output)	elapsed time to deadline
Attitude toward new facilities	cautious, subtracts from total time available	promote multiple uses, to lower unit costs	if it provides answers needed, worth what it costs
Cost factors	per item charged, labor-intensive	justify overall program, labor $\geq$ capital	total costs: time is costly; capital > labor

Many of the same parameters apply to the manager of a commercial information service and the manager of an in-house information system. Both seek to optimize the use of special new facilities which increase their capability for special projects, and in general encourage multiple uses for the same item. Their priorities in the selection of information tend to emphasize breadth of coverage, according to prescribed standards of output, so as not to miss a good reference. If a choice must be made, it may be more important to cover all sources and not all details. The work output frequently stops with references and abstracts, and bibliographic coverage may be enough. A preferred criterion of success for future demands is not the total output, but how much of it is actually used. Cost justification and cost efficiencies are examined for all items in the program, and cost benefits are considered in general for the whole operation, rather than for single items.

Planning is strict on elapsed time, and ignores or places a heavy discount on information received after the decision has been made. Background information is selected for relevance, a traceable or logical connection to the area concerned, and cannot stop with pertinence to a single point. The planner will use whatever sources he needs and can find within the time allowed, and often has well-developed sources for information outside the published literature. Within this time frame, costly special services may be justified as a capital expenditure, worth what it costs.

Timeliness of information for planning is measured in terms of speed, to meet special requests. This involves current operations. It frequently benefits from previously prepared document collections, vertical files, or abstracts preselected for browsing in areas of interest. These are available for immediate use on demand, to seek information relevant to projects being planned. Speed is essential to relevance.

Priority in the selection of useful information is addressed to overview, not details. The planner wants a collection of different points of view for looking at his problem, and is particularly interested in methods for evaluating the information available. The potential value of a given information service for future reference depends in part of the reliability with which it can be expected to present a specific point of view. Repeat business typically requests the work of a known individual. The planner is extremely conscious of total costs; time is worth money as a part of the total project. Long-range planning towards areas of future interest rather than immediate projects may be less stringent on the time scale, but is equally concerned with the evaluation of sources and points of view.

The principal point in Table 6 is that the differences observed are linked to function: they are not completely random as to the individual. Thus, relevance and over-view tend to relate to planning, where pertinence and detail are of more interest in research. These linkages can help to reduce semantic confusion. Note again that in this comparison as elsewhere we are considering only relative values, not absolutes.

Function as here defined has to do with the structure of language: information operations are concerned with doing, the present active participle. The research/development function is concerned with how to do, the art or

developing state of the art of the patent attorney. Planning management is concerned with target/evaluation or what to do, which can be considered the subjunctive mode of might or could or should. The engineer who considers himself a builder and not a researcher may prefer to define the three functions as scientist/engineer/manager rather than research/operations/planning, and the table can be read just as well with these terms as column headings. The differences observed appear to be real and characteristic, regardless of which labels are applied.

Applications of the Functional Approach

In practice, this approach has helped to defuse areas of apparent conflict in assessing information needs. Specific examples are cited. Junior staff could see that a management change in decision based on additional aspects of information may not at all represent a lack of confidence. In a small business situation, management could allow for the information priorities of both scientists and planners, corresponding to their real differences in function. The patent attorney has a strong component of planning (target selection) in the use of information, and the patent searcher he likes and trusts is the one who gets his business. For an abstract service, the opinions of the searcher on the importance of access to originals may be easier to obtain than those of the scientist, but they are not the same. For a special library with limited staff serving all three functions (research, operations, and planning) a marked improvement in the service to one may result in a definite loss in service to the others, unless an improvement can be made in them as well. In this case a review of user values has identified a "non-computerizable" skill as the ability of the staff to upgrade the input to the system; by checking the originals of documents selected from the incomplete information found in titles and abstracts.

This study is concerned with the value preferences of the user of information services, the individual scientist or engineer or person from other populations who wants to use the published literature for more than current reading. It is not directed to those who don't care. Most scientific and technical information systems are not used solely for research or for planning or for service functions, and most users are not purely rational or subjective or judgmental. The person least sensitive to the cost effectiveness of dimensions in value other than his own may be one who thinks his system could become all things to all people, if it could only get enough support. The selection and optimization of a service requires an awareness of the varied ways in which it will be valued by different users. Differences in points of view may be more readily resolved when they are recognized as multi-dimensional, and not necessarily as opposites.

1. INTRODUCTION

The rapid expansion of information research services has created an industry that tends to be ingrown, with users and producers who are their own best customers. The number of such services is well over a thousand and continually growing. Many of these services are directly competitive, and it is increasingly difficult for the potential user to know which service to select for a specific use.

This report is a study of the selection process by which different groups of users decide to buy or use different information services, for searching in the published literature. It has been conducted for the National Science Foundation, Division of Science Information (formerly NSF/OSIS) under Contract Number C-1027, as a part of the larger current NSF project on "Improvements in the Dissemination and Use of Scientific and Technical Information (STI)."

The postulate proposed and developed herein is that there are identifiable groups of users with different types of needs who differ in how and why they choose one type of service over another, in STI and related fields. The characteristic value systems applied by different users in this selection process are not the same, depending on variables which can be defined by dimensional analysis. The results obtained confirm this thesis, with the subtle but significant difference that the identifying variables relate more to use as an event than to the user as an individual.

A matrix constructed to represent these variables and patterns in use provides a convenient means to explore their similarities, differences, and linkages between them. This matrix of user-value systems was developed on the basis of individual interviews with some 30 regular users of purchased information services in various divisions of the Contractor, Exxon Research and Engineering Company. It was then tested and refined by interviews with an equal number of managers and users of information services in other companies. This checking with outside sources was stipulated in the project scope of work, as an expanded program to disseminate the results obtained. A questionnaire was developed and tested at the end of the study to examine the acceptability of the parameters selected and the definitions proposed for them. Preliminary test results and suggested modifications are discussed.

This is the first-year report in a proposed two-year project. The objective for the second year will be to examine the factors involved in the success of systems and services for information analysis. Interacting relationships to be explored include the effects of location (the information analysis center), of personnel (the analyst and the user/customer), of procedure (the analysis), and personal impacts in both directions between them. The plan for the second year includes individual interviews and case histories of a number of such systems.

As a matter of policy, no identification is published herein of the exact sources of the individual opinions and experiences reported.

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This study has benefited throughout from the supervision of Ms. Helene Ebenfield, Technical Monitor, and Joel Goldhar, Program Director for the User Requirements Section of NSF/DSI, and from critical reviews by Messrs. Isidor Kirshenbaum and Ben Weil of Exxon Research and Engineering Company. Particularly helpful comments have been received from an Oversight Review Committee including Ms. Gloria Cohen, Madeline Henderson, and Messrs. Ed Bartkus, Walter Grattidge, and Homer Sarasohn, managers of information operations or departments at G. D. Searle, the National Bureau of Standards, DuPont, General Electric and IBM.

The correlations and conclusions in this report represent a systematic study of conflicting opinions from some 60 users of information services. Their willing cooperation to explore and define areas of agreement and disagreement is gratefully acknowledged. The questions they were asked to consider were provocative or even controversial, and it is fully recognized that there are some misunderstandings which may have been overlooked or left unresolved. These are the sole responsibility of the author: it is hoped that they will stimulate further discussion.

2. DEFINITIONS

The purpose of this study is to provide a guide for the user of scientific and technical information services, to help him/her* identify his patterns of use and needs. It is addressed to the user who has decided to invest time or money for information services, and who wants to select from all the services available those which will meet his own requirements. It explores the value systems observed by different groups of users in the process of such selections, so that each can identify others whose points of view are similar or different, to benefit more directly from shared experience. The study excludes by definition a choice based on field of coverage alone: if there is only one service that covers a given field there is no choice, and it gets all the business. Usually, if not always, there is some alternative route, and therefore a choice between competitors.

The literature on the evaluation of information systems is beset by semantic confusion, with conflicting or contradictory definitions for the same key words. Much of this literature has been addressed to the design and performance of a given system or service, where our concern is the choice between services. It is necessary for the purposes of this study to give clear and arbitrary definitions to a set of basic terms:

The user we are considering may be anyone who is selecting an information service; he may be a scientist, an engineer, a library searcher, or an information analyst. In centers where these services are readily available, it may be unusual for the same person to be both "user" and customer (the one who is asking for information); more often the "user" is collecting information at least in part for someone else. "Purchased" requires that the service be commercially available and therefore viable, on the market either as a service to order or one readily available to many users. Such a service provides processed information, which saves the user from having to dig it directly out of original sources. Our study is directed specifically to scientific and technical information; similar principles may apply to other areas of knowledge with different parameters, e.g., for time or the nature of data.

Types of Service

Purchased services from which any user may select fall into three major categories:

- access tools which the user can use himself, at all levels of complexity. These include indexing and abstracting services, or computer data bases used for routine retrieval.

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* With due apologies for the English language, "he" will be used hereinafter to include "she" or "they"; "hers" is included with "his" or "their"; "himself" equals "herself" or "themselves", etc.

- paid searching for known facts, where the question is defined before the search begins.

- a service for information analysis, where the user pays someone both to find and to analyze the information available.

The distinction here is that in "searching" the question is pre-defined. Definition may be a lengthy process, but any change in the question once agreed upon is considered as a new search. It is also only a search for facts, or references, not the evaluation of facts. As a corollary of this, a commercial service which does such searching may state that any searcher on the staff, with proper training, can accept an incoming question and come up with the same answer. The customer for a search may get all the original literature and references, or he may make selections from a search report (bibliography) and request specific items. The customer does his own evaluating, either way, or arranges to have it done as a separate step after the search is completed.

"Information analysis" introduces a new set of interactions that go beyond searching: the user continuously redefines the question by analyzing the information being obtained. "What is...?" can be a simple or complicated search; "What if..." is quite different, and requires a different level of personal or staff ability and experience. This may involve conferring with the customer, or the user may do all the analysis and supply only a digested product. The same information services, even the most sophisticated ones, may be used either for searching or for information analysis: the difference lies in the user, and how the information tools and services are applied at this specific time. In any case, the information analyst is applying a higher level of skills than in searching alone, because the analyst must understand the technical language of the literature and the customer's needs, as well as the inner workings of the searching procedures used.

The value system which the user applies can be viewed as a set of interactions which determine what group of factors he considers most important in his selection of services. Principal parameters in the decision process are the selection factors preferred, the type and function of use, and the type of services.

Selection-Factor Dimensions

A dimensional approach to this complex system is recommended. There are a large number of discriminant factors which can be considered significant in the selection process. As a first step in this development these can all be categorized in three dimensions, as quantifiable, qualitative, or judgmental. This type of dimensional analysis is based on previous studies of multivariant systems for the evaluation of projects in research (see Appendix A). The idea is to group variables which are so linked that they tend to move together in any change or comparison. The list in Table 1 suggests that cost, time, physical facilities and personnel can be considered as one such group, in the dimension of

Table 1

Dimensions in Selection Factors

(Aside from Area of Coverage)

Quantifiable (numeric)	Costs - Direct - indirect	Cost/efficiency, Cost/benefits
	Completeness	Fields, numbers, %
	Time	Entry into text or index Retrieval speed Timeliness
Qualitative (ranking)	Format	Appearance Uniformity Convenient access
	Flexibility	Depth can be varied
	Responsiveness	Change priorities, Accept suggestions
	Feedback	To/from user
	Feeling aspects	"I like it" Public relations
Management Judgment (yes/no)	Reputation	"Our way of doing things" Past recommendations
	Viability	Will it work? Will it last?
	Consistency	Dependable bias

quantifiable factors. That is to say, any circumstance which has a major effect on cost, time, facilities, or staff requirements is likely to have some effect on other variables in the same group.

The background of Table 1 is explained in Appendix B. Initial interviews with a few major users of information services developed a list of discriminant factors which they consider as practical criteria in selecting between services preferred. Examination of these lists showed that the factors tabulated were all quantifiable, but there was always a column of comments which were not. Entries by different users for specific services showed quite good agreement for the quantifiable factors, but not in the comments. These were different for each user, or for the same user for different uses. Most of the comments refer to a second dimension which is well recognized as the whole gamut of qualitative factors that cannot be measured exactly, but which can be handled by the technique of subjective ranking. The exact names given to different factors or relationships in this group are harder to handle than the fact that so many of them tend to be interrelated, and to move together when any of them is significantly changed. Differences and relationships between quantitative and qualitative factors are frequently recognized in the design and optimization of information systems. One such statement is that if you can completely structure the input to the system (the definition of user needs), then you can structure the output (what type of service or report will meet these needs) and the qualitative aspect tends to vanish as a variable (see Appendix B). Stated differently, if you can give the customer a product he likes and wants to use, he doesn't care too much about other aspects of quality.

The decision process is not based just on facts and personal preferences, however. There is an elusive element of judgment or "common sense" which is not either quantitative or qualitative. Eloquent testimony on this can be offered by many a development engineer who is baffled when management has turned down a pet project that looked good on paper. Management judgment tends to be a yes/no answer. This judgmental dimension is hard to argue with; it is based on neither numerical facts nor subjective rankings alone, but on a blend of these with intuition, based on experience. The evaluation of reputation, suitability or future prospects often involves a major contribution from the judgment of other managers. It is harder to define and is less often discussed in the literature on information systems than either cost or cost/efficiencies/benefits, but perhaps this is only because it is so often deferred to others and then taken for granted (see Appendix B).

Quantitative and qualitative variables can be characterized as rational and subjective. After consultation with behavioral analysts, the dimension of business judgment was recognized as correspondingly "intuitive." The dimensional approach on this basis has the advantage that the categories named are complementary, not opposites; it is therefore less likely to leave holes in the Matrix of values and interactions.

The list of selection factors in Table 1 is by no means all-inclusive. It carefully avoids some obvious words such as "reliability," which could be put several places but with quite different meanings. Many discriminating factors (such as completeness or accuracy) have effects in several dimensions. As these effects were examined more critically during the study, it appeared that the special meanings or implications attached

to key words (such as timeliness or intended use) are a characteristic part of the distinction between different groups of users. The starting point is that dimensions in the selection process can be recognized, regardless of the exact names associated with them, and that they can be used to characterize parts of the selection process.

The literature on the evaluation of information is biased, at this point. Part of the problem is semantic. As a point of departure, each author tends to invent some new word or attach a limited special meaning to an old one. Such articles are often contradictory, reflecting strong individual points of view. Much of this literature is written by the purveyors of information services who emphasize their concern with matters of cost, or by system managers concerned with the value of time. These groups agree with each other on the importance of cost, however, although other users may not. There is a basic reason for this: both are in a sense vendors who must sell their time and services to someone else to stay in business.

This information-evaluation literature seems to have started with heavy emphasis on factors of cost (1), changing gradually over the years to include cost/effectiveness and cost/benefit factors (2-7, 8). These are progressively more difficult to quantify, because they involve subjective elements (9). Many authors have recognized and bemoaned the problems of evaluating complex variables containing both objective and subjective elements which cannot be exactly measured (10). The total number of factors recognizable in the selection between services can be expanded almost at will: a recent checklist recognizes 144 of them, under 7 different headings. Many of these are closely linked, however, and they are not stated as independent variables (11, 12). Judgmental statements tend to be kept out of the open literature or to be phrased vaguely, in general terms, regardless of how important they may be in the decision process (10).

User Populations

Identifiable groups of users are found to differ sharply in the value systems they apply, in deciding what services to select for a given use. The grouping of selection factors into dimensions tends to be confirmed by parallel differences in their appeal to different user populations. This study started with selected heavy users of scientific and technical information and services for access to it. Those interviewed included scientists, engineers, patent attorneys, information searchers and analysts, planning staff and managers. These user populations can be conveniently grouped into three categories, as suggested in Table 2, on the basis of whether the information they most frequently want to have "hands-on" for their own use is original documents, selected references (by title or abstract), or evaluated overviews. The identifying characteristic proposed to distinguish broadly between them is their function in the use of information: for R/D, for information operations, or for planning.

Table 2

User Population Characteristics

User Populations	Typical Preference for "Hands-On" Access	Special Concerns
Research Function		
Scientist	all pertinent originals	reasons for differences
Engineer	representative originals	data, design details
Patent Attorney	highly selected originals	exact wording
Information Operations		
Searcher	references requested	coverage pre-defined
Information Analyst	selected as relevant	optimized during search
Planning Function		
Planning staff	all viewpoints	evaluation methods
Manager (planning)	overview of field	reliability of elements

Users concerned primarily with the research function include scientists, engineers, and attorneys. These are professional men whose information need is for original documents, although for quite different reasons. The scientist frequently wants to study and compare different sets of original data, or the methods by which they were obtained. The engineer usually wants a single set of reliable data, not all the data that there are. The attorney drafting a patent application or a new agreement needs the complete and exact wording of selected originals, but is less concerned about data.

Differences between engineers and scientists in their usage of information services were noted in initial interviews, and confirmed in discussions with a number of information managers and librarians. Statistical data in support of these results were then obtained in the preliminary results from an internal survey by questionnaire (see Appendix C). The typical engineer tends to rely first on information from handbooks or from colleagues, and particularly from company reports and correspondence. When he asks for a literature search, he is usually satisfied with seeing whatever selected references are readily available. The same tendencies appear in both engineering technology and in engineering design. These observations are fully in line with previous studies in the literature (13). The research scientist also wants his references as quickly as he can get them, but he is often willing to wait for days or even weeks to get the last article on his selected list. There was a unanimous agreement among engineering librarians that this distinction between the typical scientist and the engineer is real.

In information operations, the user concerned may be a paid searcher or analyst, or the manager of a system providing such services. It is worth repeating that this study is seeking the viewpoint of the user of services rather than the producer or vendor, even though this may be another function of the same individual. The searcher (the individual who is acting as a searcher and not as a scientist or as a manager) is frequently satisfied to stop his search with an abstract that identifies useful source documents; he may not require their physical production, but leaves this choice to the customer. This difference between the viewpoints of the searcher and the research worker has a significant corollary in the value of access to the original. The searcher is satisfied that he has added a valid reference to his report, but the selected reference which cannot be found after concerted efforts has a negative value to the customer for wasted time and effort. The abstracting or indexing service whose "customer feedback" comes mostly from searchers will not get this reaction as strongly from them as it would from the chemist or other customers (see Appendix C).

Planning is a function of management which is often delegated in varying degrees to others. Outlines of policy for the selection of targets may be prepared by a special planning staff, or by other levels of personnel. The planning function involves special sources of information, often unwritten, for such matters as organization policy or future prospects. These include questions entirely different from either the quantities of costs/budgets or the subjective qualities of performance, relating closely to judgment and experience. Lacking personal experience with the services to be selected, the managers interviewed said that they would rely on other sources of judgment. They suggested reasoning by analogy, considering the opinion of another manager they can trust, or the reputation of the producer as an individual or as an organization. "Organization" in the generic sense includes any enterprise such as a library, university, agency, or corporation involved in the processing of scientific and technical information.

Planning is concerned with the selection of targets for future work. The planner is typically pressed for time, and more interested at the moment in an overview or digest of information than in details or exactly where to find them. He wants immediate access to relevant ideas, available viewpoints, and suggestions on how to evaluate them. His problem is quite analogous to the hunter selecting what weapons to take to hunt for squirrel or partridge or deer, and selecting a strategy to suit the target. He has secondary but vital choices such as to what to do if he comes across a bear, and the most important actual choice he may have during the day is whether to quit looking for deer that aren't there and pick raspberries.

3. MATRIX OF VALUE INTERACTIONS

The Matrix diagram presented in the Summary involves a complex system of variables, interactions, and changing values which different users apply in their selection of services. The matrix approach helps to indicate that certain patterns and linkages in the user's choice are predictable. The push/pull effect of related factors within a given dimension has been discussed: push either personnel or facilities and you affect time or costs; push either reputation or suitability and you affect future prospects. The Matrix rows present the major variables or elements defined above: dimensions in selection factors, user populations, and types of service. Matrix columns represent how these variables are defined, how they are perceived by the user, and how they interact. User/function interactions appear in the different priorities in value assigned to selection factors in each dimension; user interactions with the event or environment of use appear as concerns of the user, management, and the specific project.

The Matrix also helps to emphasize that the concepts involved are all considered as relative, not absolute, as preferences in a dynamic situation. The development of the matrix is outlined in Appendix B: interviews, initial analysis, preliminary conclusions modified, tested and redefined among different users and managers, so as to be acceptable to each. Preliminary results specific to scientists and engineers were augmented and confirmed by a user-survey and questionnaire, whose development and analysis are outlined in Appendix C.

Priorities in Selection Values

A simplistic statement can be made for any user who has a choice: he wants the best service that he can afford for his use. Differences arise when the individual as user is forced to consider what function he is serving at the time, and what selection factors he considers most important for that specific use. The searcher and the scientist differ, and neither of them gives first value to the factors of cost that seem so important in the literature. Value preferences expressed in interviews with different user populations suggested the following apparent relationships, which are summarized by function in Table 3.

Table 3

Value Priorities According to Function of Use

Dimensions of Selection Factors	Apparent Priorities in Order of Importance
Quantifiable, Numeric (Cost, Time, Facilities)	1 - for information operations 2 - for planning function 3 - for research function
Qualitative, Ranking (Subjective, Convenience)	1 - for research function 2 - for operating function 3 - for planning function
Judgmental, Yes/No (Intuitive, Experiential)	1 - for planning, management 2 - for research function 3 - for information operations

- The scientist/engineer chooses first of all the service he finds most convenient to use. He accepts the judgment of a manager as to what systems to consider, but he pays relatively little attention to quantitative comparisons of costs or facilities as long as the systems available give him the answers he needs.

- The planning staff or manager makes a first choice on whether the service in question is reliable, likely to stay in business, or "suits our way of doing things." The planner tends to consider budgets on the quantifiable factors overall, and may include qualitative factors only after he has ruled out services that he finds unreliable or too expensive.

- There is a considerable body of literature on operations which implies that all other values can and should be linked to cost, time, and the quantifiable factors a service manager or vendor must control to keep his customers. Qualitative factors may be recognized in cost/benefit studies, but somewhat grudgingly because they cannot be accurately measured. Judgment as a separate dimension is well recognized in discussions on business management, but not so clearly in the literature on information services.

It must be emphasized that all of these factors are recognized by all the user groups, but in an entirely different order. The cost of an information service, for example, appears to be less significant to the research scientist than convenience or reputation: this is not to say that costs can be ignored, but only that the scientist is more likely than the vendor to put other factors first.

The order of priority is clearest for each function to what choice comes first, and secondary choices may vary. The information analyst, for example, carries out an operating function in searching and a research function in evaluating the information found. The patent attorney is assiduous both in searching and in planning, not necessarily at the same time. Earlier drafts of Table 3 named user groups for each function and ran into difficulty in where to place the title "manager". It seemed first to belong with "planner," but on further thought it could belong just as easily with the searcher, or, the manager of research. This forced the realization that the manager views things differently when he is concerned with the function of research, or information operations, or planning. Furthermore, from this viewpoint, the priorities of the manager and the user/worker are much the same, for a given function of information services. It is the function, not just being a manager, which appears in Table 3 as the identifying variable.

Environment of the Use-Event

The environment of use is part of the dynamic Matrix. Personal impacts, management concerns, and the nature and maturity of the information project interact constantly with the user in his selection of services. In general these interactions enter into the Matrix as parameters or operating principles, which may help explain to the user why his priorities in selection are what they are. Appendix A includes a background discussion on the overall impact of rapid changes in technology. Subheadings which illustrate these effects are listed in Table, which presents a matrix expansion index. This shows the relationship between the summary table and additional details presented in the text Tables 1 to 6, for various parts of the Matrix of values and interactions.

Personal impacts of the working environment on the user include limitations and positive effects, both direct and indirect. Freedom of choice between services may be sharply affected by limited authority for cost approvals, if it enters into a restricted area within which approval by someone else is required.

- Within the user's limits of approval, the "free vs. fee" argument constitutes a hazard when it imposes a forced cost decision on users whose value system would always place convenience or quality first. Their skills in the budget/cost area may be so poor that a forced choice is arbitrary or capricious, ignoring cost/benefit trade-offs that they would normally defer to someone else.

- The restricted area where a second approval is required tends to repress rather than encourage the use of "fee" services -- all such service, not only those which are most expensive.

- An alternative which does not discourage use of the proper information services is to define some area, starting with free access to the library, within which the professional participant or employee can select which service to use. Each operating system draws its own lines between services that are free, or easy to request, and those that are charged to a group or to a specific project.

Another personal concern is whether the information worker has himself the skills and facilities for direct use of the information he supplied. This does not mean that he is going to use the information, and it is not the same thing as knowing how to use the service. Personal experience and capabilities have a direct influence on the ease with which the worker can find and select information he understands (14). This applies particularly to the user/worker who is doing a search or information analysis for someone else. Two questions of this type are related:

- Does the searcher or analyst know how the information will be used?

- Does he know what specific information would be most useful, if it could be found?

These skills can either enhance or limit the value of the information selected. They need not be actually used, if they are familiar and understood, Such information can be processed very quickly and fed back into the system, to define a desirable new search or a new approach in analysis. Facilities for testing do not necessarily mean laboratory equipment or field units; many types of information can be tested out in other ways, say by computer modelling or by discussion.

Personal interactions include the user's evaluation of the aspects of information handling in which he feels that he is using his own highest skills. This has two effects: in such an area the user tends to choose the services of a specific individual, whom he feels he can trust, or he may want to reject any such help as undesirable interference and do this part of the work himself. The aggressively individual researcher may reject any analysis of original references by someone else in his areas of special interest. He prefers to find for himself any research leads or holes in the data. The planning manager may consider one of his essential tasks as browsing in selected sources to find potentially useful information from results in another field. For any user, the impact of paying someone else to think for you in information analysis may mean that you want to know exactly who is doing the work, and to be notified at least if the individual analyst is changed part way through the search. This personal impact varies with the type of service, as indicated in the Matrix: it is high for information analysis, and low for routine access tools.

Table 4

Matrix Expansions

(see Matrix, Summary page ix)

Variables		Interactions
Selection Factor Dimensions (see Table 1; B-2)		Users' Priorities (Table 3)
User Populations (see Table 2)	User Functions (see Table 6)	
Types of Service (see Definitions)		Environment of Use (Table 4,5)

Interactions with Environment of Use:

Personal Concerns of the User-worker

approval authority limitations, repressive effects
forced cost decisions; areas of free choice

experience on how the information will be used
what would be most useful; immediate feed-back

areas perceived as own highest skills
reject help or choose the person; browsing; analysis

new techniques as a status symbol; economics
expand utilization if cost-justified; operations vs. research

vulnerability to negative data or wrong information
research can benefit; planning less strict as to source.

Management Concerns

partly matters of individual style, as much as company policy
total time allowed for information vs. other work
either individuality or team effort can be overdone
is innovation desirable or only a threat to present lines
any premium allowed for quality of information, or special areas
debits for alternatives: quick answer, best answer, no answer

Project Maturity

how essential is it to get how much information

types of search: for background, project definition, R/D, patenting
evaluation of government agency requirements, publications, proposals

depth of search: breadth, detail, when to stop.

The interested user finds a certain satisfaction in knowing and using the newest and most sophisticated techniques, and is likely to invent reasons for using them as part of the learning process. This is valid if the purchase or availability of the service selected has been justified on other grounds, not just as a pretty new toy. The experience of firms which overbought on computers is very much in point. This hazard may be reduced by trying the basic cost justification for special facilities to actual extent of use, and allowing only incremental value to new functions that are expensive but seldom used.

The time and costs which different managers are willing to allot to special new service features may differ radically as a function of use. The vendor-manager wants to find new features that he can add to his service as selling points, at minimum production cost, to make his product sound unique to potential customers. The manager of research or production will not resist if this meets an unfilled need, such as a fail-safe system for patent problems. He does not want to keep paying for a special feature if it is rarely used, and he will guard carefully against wasting budget dollars or the time of his people to receive or process information that they don't need. The operating manager of the information system is in between: he seeks to maximize or to find multiple uses for new features in the systems that he has bought, since they increase the overall range and flexibility of his operations.

Completeness and accuracy may be taken for granted in a service where performance standards are maintained. This is not always true and where it is not, these parameters quickly become vital. Vulnerability to poor information or negative data from the literature varies with the user and the specific use. It is high for any quick answer, which is taken at face value. Wrong data can be a significant factor in the reputation of a service, downgrading judgments on reliability for future purchases. This is not the same thing as negative data, or even unreliable results which are properly reported. The research planner may derive definite advantages from detecting a result which seems out of line compared to some observable trend or average, and in exploring the reasons for this discrepancy. Uncertainty or negative data can be an important part of the total picture. This can be a nuisance in searching and even more so in planning, unless the uncertainty itself is important enough to become a target for study.

A definite lack of concern for the scientific quality of information applies to certain operations of the planning staff. The planning manager, seeking a quick overview of the information available in a field new to him, wants the widest variety of points of view which can be applied in evaluating the situation. He is not overly concerned with whether a new viewpoint comes from a Nobel Laureate or a tabloid editorial, since he is trying to look at things from all angles. The tabloid bias may be just as important to him, or even more so, if he wants to examine where this bias came from and what if anything can be done about it.

Management concerns are a major element in determining the environment of use. Each manager makes a basic choice as to the importance which he attaches to scientific/technical information as a whole, from any source, compared togoing out in the shop or the field to get new data. Choices in this area may be a matter of individual style, as much as company policy: a popular average value is from 10-20% of total professional time allowed to acquire and process relevant information. This may vary from zero to 50% or more at times, but the manager who values the information approach will allow extra time for such work, where the manager who is unsympathetic may not. Most of the information scientists interviewed in this study agree that the basic time allowance which the manager sets for the people under his direction is changed very little by the success of a new technique. A few are more optimistic, but there is a strong consensus that the time devoted to more effective information services is essentially subtracted from less effective sources of information; total time allowed will remain the same.

The choice between individual research vs. team efforts is a matter of company policy, as well as the managers involved. Information analysis tends to flourish in a team environment, and it may be less appreciated where individuality is strongly emphasized or completely denied. The emphasis on individuality can be overdone either way, with complete isolation between workers or none allowed, and the interaction of selection factors in this area merits further study.

The importance of innovations also depends on whether management does or does not want anything new. A new development may be a threat to business, of direct interest in a competitive situation. Or it may be a threat to established practice in some specific aspect of the business where a change is deemed inadvisable for any reason. In either of these cases, the information desired may place heavy emphasis on finding reasons why the new development will not work as described. The normal assumption is that innovations are desired, but that such information is mostly for current awareness and much less often for specific action.

The question of whether there is or is not a premium on the quality of information supplied for a given request depends partly on the specific project; but it often involves matters of company policy as well as the manager's style. Whole areas of casual interest may be defined in which only superficial information is desired, with no premium for details, and other areas where specific details are of interest but no action is planned barring some major surprise. These serve as exclusion parameters, to narrow the area in which it pays to even consider coverage in depth. Management policy as to the extent of concern in a whole related area enters into the decision as to the depth of search: is the area worth while, regardless of the specific project? Alternatives may be compared in terms of the risks involved in accepting a quick answer, or no answer, rather than looking for a best answer to the question involved.

The time constraints which apply to any search for information include several different variables. Times for performance which are of interest for research or for operations may include the time for soonest notice under favorable conditions, and some measure of the risk of late notice when things break wrong. Both are vital for patent problems, or for competitive developments of special interest. They are measured only approximately by the average time for performance, which the vendor of services would like to use as his yardstick. All of these refer to the time it takes for the service to process information from the current literature into its finished product. In an abstracting or indexing service, this processing time must include whatever indexes or other means of access are normally supplied and required for effective use in retrieval, as well as for current awareness.

The time constraint for management includes time to let the information "soak," to rebalance the rational and subjective and judgmental inputs in reaching a final decision. Similar parameters of time apply to the problem of the retrieval and use of originals which are difficult to find, as noted above, for users who require the original to meet their needs. The extent to which these requirements are met enters into the reputation of a service for future purchases.

The tolerance allowed for extra time to reprocess information as received before it can be used is another variable. The concern for such extra time can be a major threat, when there was a need or expectation for direct use. The supply of more information, even if it is better information, only makes the problem worse if it still has to be digested and there is no time available.

The question of timeliness has quite different meanings to different managers and users: appropriateness for unscheduled need, dependability according to schedule, or immediate response to urgent request. These can be linked directly to the function of use (for research, operations, or planning). Similar conflicts in meanings and implications are found for many parameters in the selection process. This is discussed further below (see Table 6).

The maturity of the specific project interacts with both the user and with management concerns in deciding what type of search is desired. It enters directly into such questions as to how essential it is to get how much information, and when. Breadth of coverage, detail, and when to stop are interactive decisions which apply at all stages of urgency and justifiable expense.

Types of search which may be required at different times are summarized in Table 5. The arrangement is essentially chronological, and in increasing order of urgency. This table was derived from variables identified in different types of patent searching and generalized for other areas that are now equally important. Patent searching is one of the earliest areas where differences in procedure were systematically developed for different types of information need.

Table 5

Types of Search at Different Stages

Type of Search	U	Project Stage	Characteristic Concerns
State of the Art	project planning, background	for research, patents, marketing, or manufacture	broad view, moderate depth; what has been done and how
Novelty	specific data, positive or negative	during research, patents, marketing, manufacture	what works and doesn't; methods, what will appeal to the public
Contracts	define limitations, ranges, alternatives	for negotiations, infringement study	what will other managers pay for
Liability	civil limits, caveats, government regulations	all of the above (FDA, EPA, etc.)	evaluations, differences, best technology; ultimate effects

A broad state-of-the-art review before project planning may be requested as background for research, patent planning, marketing, or manufacturing. The novelty search is more specific: it is needed once a project has been defined, to determine what direction is best for the new development. This also applies to the complete spectrum of use, for research strategy, patent drafting, market development, or methods of manufacture. While contract negotiations often center on patent infringement, they may be generalized to define and clarify those aspects of new development that someone is willing to pay for. The overriding question of liability has been broadened far beyond the caveats of business law because of the government regulations issued by a large and growing list of agencies. The Food and Drug Administration and the Environmental Protection Agency are typical. This effect is discussed further in Appendix B. The very large requirements which these agencies set for complete evaluation, best available technology, and environmental impact statements represent a significant part of the present total demand for special information services.

A major information search may include any or all of the functions of research, operations, and planning, to provide background for project definitions, evaluation, patenting, publication, or proposals to management. Any of these types of search can be broad or narrow, simple or complex, short or long. Depth of search and the decision when to stop are parts of a dynamic process. In general, you stop when you get a good answer. In reference calls to retrieve a specific document or a known fact, the answer is obvious. The less defined your needs, the more expensive is the service. In a patent novelty search the right answer may be just as obvious, but either simple or far more difficult to obtain. Breadth of search and the number of special services employed can be expanded indefinitely in many such cases, depending on the skill of the searcher and the importance of the subject. The customer (attorney) in such a patent search may do all of the analysis of references supplied and make all the decisions for search, or he may employ the services of an information analyst who can conduct and modify the search more or less completely on his own. The more complex the search the more continuous is the interaction required, whatever type of use or service is involved, and the more important it is for the service to be able to accomodate and if possible anticipate these changes in depth and direction.

Conflict in Meanings of Key Words

The semantic confusion of conflicting connotations for the same key words can be reduced by associating sets of meanings with each of the functions identified. This is an end product of working out definitions which are acceptable to people who disagree. Conversely, these different sets of connotations help to characterize the functions with which they are linked. This is illustrated for eight "parameters of value to the user" in Table 6, which appears in the Summary (page xvi) with accompanying text.

4. CASE HISTORIES IN SELECTION FACTORS

The examination of variables in the selection process and linkages between them started with the search for identifiable user populations and dimensions in their evaluation, as discussed above and in Appendix B. Surveys and interviews developed as empirical concepts the interaction effects of user priorities and the environment of use, linked to the function for which the service is desired. Actual case histories noted during this development illustrate typical situations where a number of variables are involved, all at the same time. As a matter of policy in this report, locations and examples are not specifically identified.

Initial Purchase of an Expensive Service

The first example referred to an expensive indexing service which had been examined on a trial basis at a central library but left untouched on the shelves and returned to the vendor. It was unfamiliar to potential users, and required training to be useful to them. While the initial reaction was negative, "trade information" over ensuing years indicated unique potential advantages and satisfactory experience elsewhere. On a subsequent visit to the vendor an improved indexing system was offered, based on additional years of experience, but requiring a substantial initial purchase cost. By happy coincidence, upon returning from this trip, the manager concerned was informed by Accounting that an unanticipated balance of $X,000 was left in a capital reserve account, and the new service was purchased at once. Six weeks later Accounting called again to say they had made a mistake, but by that time the new service was already in use, with enough experience to easily justify its continued cost.

Analysis of this story reveals several factors: first, the "energy barrier" to the initial purchase was apparently too high. Along a different line, this and similar experiences in the evaluation of research innovations suggest that a successful experiment is frequently accompanied by what appear to be lucky breaks but are in fact a basis for serendipity or management hunches, based on experience. The exact converse of this is that in experiments which turn out to give negative answers, or failures, there appear to be many unexpected gremlins or quirks which there was no logical reason to anticipate. The frequency of such events suggested that intuition or the manager's hunch is in fact an essential dimension to consider in the decision-making process.

A second case history identified was somewhat analogous. In this case a major service offered in several sections had been purchased (in part) by an affiliate library, based on information in sales brochures. It had piled up unused on the shelves because of the considerable clerical time required to set it up and get started, and to interfile additional sections as received to keep it current. A major search request was received at the research center which could justify the time to convert this file to usable form, and it was boxed up and shipped off promptly by the affiliate which was glad to clear its shelves. The result again was

a complete success, and led to expanded usefulness based on further experience. These cases confirm as major variables in the selection process, the personnel time required for maintenance and training, as well as initial and continuing service costs.

Selections for the "Approved List"

The normal everyday problem confronting the user is which information service to pick from a list of those already available, not the purchase of a new service. The approved list of services he finds at hand is based on decisions made at another time and place, frequently once a year. While this previous decision is based on contributions from all users of the service, the individual may be quite willing to defer it entirely to someone else.

Almost any user of information services has access to the services of some manager whose experience he can consult, for daily use as well as for additions to the approved list. This is frequently the manager of an information center or the manager of an information service. Both of these are vendors of a product which they must sell to stay in business. They share a common interest in prices, production costs, and quality standards which can be set as specific targets. Quality standards cover a very wide range: managers interviewed report that many services have no standards at all, except to get the information out. Some of the simplest quality standards are the requirement that every item of information supplied must come from a known source, or the ability to train staff so that the same question can be given to different searchers and come up with the same product.

Cost comparison between competing services is an area of decisions most frequently deferred by the worker to someone else, in administration or management. It is a common observation that the scientist or professor or supervisor who decides to use a service on hand is actively annoyed by being asked to think about costs, and if the requirement is enforced he identifies it with discouragement.

The administrator who makes these decisions finds that simple cost comparisons for budgets and accounting are tempered to allow for differences in the service offered. The assumption is that market forces keep directly competing services close to each other in price, and that the service which costs more has something more to offer - if this feature is one you want to buy. To the extent that this is true, cost becomes a secondary factor in the selection between services, as long as they are within the same general range. This may be entirely contrary to the trade literature published by the vendors, who are highly cost conscious and anxious to use this point as a selling tool.

On this basis, there would be only three significant ranges of cost: on the market, too cheap, and too expensive. Differences within each range might be considered as relatively unimportant, although varying over as much as one order of magnitude including the average. Prices far

below the average are suspect, because they suggest dangers to privacy or some defect in the service offered. Adjustments are necessary for the number of customers, varying from a service which is cheap because of cost sharing to a service which is proprietary and expensive because any distribution to other customers is rigidly excluded. Prices within perhaps 50% of the average are assumed to correspond to desirable extra features or allowable omissions, and may not be questioned seriously as long as the user has made up his mind as to what he wants. Prices above this range bring in new questions of their effect on total budgets, of available alternatives, and of the probability of use sufficient to justify special purchase.

An example of this factor of cost by range is the decision of a central library to cancel its standing order for continuing index volumes in a series such as Beilstein, which are recognized as valuable tools for access to information. The problem is that Beilstein in Supplement IV has now reached the range of $400-500 per volume. Five such volumes appearing at unscheduled intervals in one year can ruin the book budget in even a fairly large library. Prices so far above the average force the careful consideration of alternative sources and procedures, no matter how useful the item.

The question of probable extent of use interacts with costs somewhat differently in different ranges. For average costs, even within budget, many libraries insist that a single user must make the purchase recommended with his own funds, unless he can demonstrate that the service will enjoy multiple use by others as well. This requirement is most likely to be waived for requests of low or average costs, in a new field of interest, where there is a presumption that others will become users after the new service is made available. Predictions of probable use and acceptance become more useful with increasing skill and experience.

Special Topic Bulletins

The opening of any new field of scientific and technical information is likely to be greeted by one or more new newsletters or special bulletin services, as soon as it can be expanded into a recognizable market. These bulletins may be aimed primarily at the planning function for a small user who does not have his own information service. This may be an individual in even a large corporation, however, in a new field where interest is limited, or where the user does not know how to ask for information. Since these services are expensive and tend to become full of trivia, special quality factors can be developed for their selection including such criteria as the following:

qualitative

- items come from primary sources, not just old material
- information cumulates, access routes supplied
- tied to known sources, improve access to other material
- suitable for browsing, organized by related ideas
- honest claims as stated, for breadth and depth

judgmental

- reputation of publisher, probably a quality product
- importance to major company interests

quantitative

- priced within the current market range.
- number of readers, sufficient to justify central purchase

As a "selective reminder" of relevent information for planning use, these services are in competition with S.D.I., the trade literature, and review articles in the standard journals. The one characteristic in which there was the strongest agreement in planning staff interviews is that a special information service may be of no help unless it is provided by an individual whose judgment can be trusted, based on experience.

A University Science Library

A comparison of the work environment and other variables between a University and an industrial research laboratory indicates some shifts in emphasis in the selection of purchased information services, but many of the same principles apply. The following list was suggested at a nearby University Library of Science and Medicine:

- The Library does no searching as a regular service, for itself or for other people, but only provides tools for others to use.

- Semi-public use of the facilities by unskilled users creates serious problems of misfiling, as compared to the industrial library which may enjoy a more protected environment and users of higher average skill. Thus, the University Library refuses to purchase card services, or loose-leaf with a steady flow of supplements, because they involve a block of time to get into business, interminable interfiling thereafter, and the constant hazard of items which are lost or misfiled.

- The Library is leary of highly specialized materials, and requires a minimum number of users, no matter who they are. This applies particularly to special interest newsletters, which are used for retrospective searching very seldom, if at all.

- Any individual research project or contract reports can be terminated, and leave an orphaned, broken file. An index or access system which is needed by only one man must be purchased and maintained by him, therefore, out of project funds, regardless of how valuable it is to him. Such a file may be transferred to the Library at a later date, but only after sufficient use by others has been established by experience.

- Uniqueness of a given service on the market compared to its competitors comes before cost, in deciding which ones to keep and which to discard, although both factors must be considered.

Upgrading the Special Branch Library

The problem of how to improve the operations of a special branch or departmental library without losing its advantages or even destroying it goes deeper than personnel. It involves what the system is and why it exists. The small special library may be in essence an expansion of the personal library of the department manager, created as a service center and not just as an information source. It operates in a closed market, which is not likely to be expanded regardless of any improvements. The special services it offers serve the department staff as a way of doing business, and limitations on the time of its user/customers are as stringent as limitations on cost.

A detailed analysis of such an operation was made for the special library serving an environmental health research unit. The first conclusion was that even this small unit covers a complete spectrum of demand, in its use of literature services. Toxicologists are doing basic research, with heavy use of the published literature. Industrial hygienists are operating engineers, who consult company sources first and find the literature less informative. Management planning is concerned with government regulations and new areas where it must be able to get relevant information immediately on demand.

All three groups are users of information services, but in quite different ways. In this particular location, the typical research/toxicologist likes to do his own searching, asks the librarian where to look (and whether it is worth looking), wants the special search files kept up to date, and often wants to get specific references in the original. The industrial engineer/hygienist wants the librarian to provide the search, seldom does his own, and is usually satisfied with a collection of whatever references are typical and available. The manager requires the monitoring of specific government documents and company literature, and likes to get on his desk with the new item a pre-selected "vertical file" or relevant documents and reports.

These three groups correspond closely to the three functions of information use outlined herein. To a certain extent there is a tendency for each group to assume that its own part of the operation is most important, and take the others for granted. Thus, upgrading any one aspect of the operation is not a complete answer. Success may backfire and make other users suffer: if an improvement in one function alone makes that part of the service better and justifies an increased demand, the limited time of the staff must be taken away from others, unless improved efficiency can be engineered to release time for other functions.

In this specific case, an analysis of the special services performed by the staff was made to define those skills which are valued most highly, both the staff and by its customers. The primary skills identified were (1) upgrading the input to the system by selecting and re-abstracting all originals of selected documents, for hidden data or meanings not adequately recognized in the abstract (or in the original); (2) creating pre-selected vertical files for major areas of current or expected interest; and (3) a current awareness and retrospective guide for where to look, for what is in the files.

These "premiun skills" are listed in the inverse order of which ones might be helped most easily by improved computer services. Thus, the guide to what is in the files may need only shallow indexing for the company literature, and the basic research literature will benefit more quickly from commercial services shared with users at other locations. Computer services may also be able to assist in items (1) and (2) by providing the staff a selected input for special processing, but without in any way replacing the total operation.

The basic principle in this case, as elsewhere, is to look for help in areas that are weak, so as to preserve strengths and provide more time to use them to advantage.

5. CONCLUSIONS

The Matrix of variables and interactions proposed suggests a number of relationships which have been stated above. Some of these have both positive and negative elements. The positive statements can be summarized first:

- Use as an event is much easier to describe than the user as an individual. The same individual may be a research scientist today, a searcher for a known document tomorrow, and a project evaluator next week. His needs and choice of services to fill them change directly for each function or role.

- The concept of user value-systems is an extension of the identification of user-groups by function. Users concerned with the research function appear to place the highest value on qualitative factors, the operating function emphasizes quantitative factors (cost/budgets) and the planning function the factors of management judgment.

- The fact that an item of information is new to the user may be enough for some (R/D planning, marketing), but for other users evaluation is vital (patents, contract negotiations).

- Cost is a strong factor in deciding whether to purchase services or not, but once this decision is made, relative costs of the same order of magnitude may be only secondary in the choice between services.

- Information analysis differs by definition from a search routine which "anyone with adequate training can carry out and get exactly the same anser." The value judgment and skills of a specific individual are a necessary part of the product.

Negative Conclusions or Unlinkages Observed

Many conclusions can be stated more cogently in negative terms, as "unlinkages" or false correlations to be avoided:

- No matter how thoroughly well developed any one dimension may be in the user-selection process, it runs into the law of diminishing returns. What is most needed is whatever is missing - a bit of public relations or common sense, or cost data, as another valid way to look at matters from an entirely different angle. The person least sensitive to values in another dimension may be the enthusiast who thinks his system could become all things to all people if it could only get enough support.

- A forced decision between services based on direct dollar costs may be a bad decision if it has to be made by a user who prefers to think in terms of quality and is not trained in cost/benefit analysis. Costs are important for the operating manager, but most users put convenience and reliability first and consider costs only within an order of magnitude.

- There are negative values, not zero value, for information which may be attractively packaged but never used. There is a recurring debit each time this item is considered and rejected again; it takes up space and time, and the system would be better off without it. This minus value can be projected in mathematical terms as a vector transform, from an origin in wishful thinking to a revised basepoint of more realistic needs.

- There are also strongly negative values for an "important reference" for which no original can be found, for information received too late, or for any information which is rejected for cause and left in the file without annotation, to be either wrongly accepted or reprocessed for another rejection the next time around.

- Time involves major factors in indirect costs which are often overlooked, particularly the time required by the user/customer to reprocess information which cannot be used directly as received (e.g., a 3-inch stack of computer printouts).

APPENDIX A

PROJECT APPROACH

Bias As a Working Tool

It is an interesting exercise to read backwards through the transcript of a panel discussion on information systems and services, and discover how easy it is to identify (without labels) who is saying what. Differences of this type appear during the evaluation of any large body of information, involving the value judgments of different men from different points of view. How to handle subjective differences in these points of view can be a serious problem, that is not always recognized. One approach to this was developed in a project on the "Evaluation of Soviet Research in Catalysis," completed at Exxon Research and Engineering in 1970 (15). The problem in this instance was that the ratings of the experts in different parts of the project were difficult to handle, since they were more or less heavily biased; many of them said the Soviet results were no good at all.

In this case, some 6,000 pertinent abstracts were collected from the Soviet literature and rough-cut into a dozen subject areas. Each subject area was assigned to a cognizant expert, who selected from his set (or reclassified to other sets) those items which he felt to be most significant for further study. These items, representing about a 10% sample of the whole, were then critically evaluated by each expert for his own area.

The ratings of these experts were then collated for further analysis. At this point it became apparent that in many cases the same project or program had been rated quite differently by different experts, each from his own viewpoint, and these ratings were not at all compatible. The next step was to consider as a group all of the ratings of a given expert. When this was done it appeared that one expert might feel that in his area all of the Soviet research suffered from a serious lack of experimental data. For him, the statement that a given report contained some poor experimental data might turn out to be the highest compliment he offered. An effort was made to determine the bias used by each expert, and his rankings were then arranged in the order of what seemed to look the best to him, within the constraints of his own vocabulary. On this basis there was a much closer agreement between the experts.

The next step was to identify and then compare the differences in the bias of different experts, to look for a second generation of conclusions. One of these has already been mentioned, in the apparent difference in the attitude of Soviet and U.S. scientists toward the importance of experimental data. This derivative conclusion could be checked independently against the observation that some of the best-known Soviet scientists in catalysis (e.g. Balandin) seemed to be quite erratic in the quality of the data they reported. It appeared on further study that the quality of the data in these instances could be correlated well with the later quality of the work done by the junior author, but not that of the senior author at all.

This approach is similar to the perturbation analysis of astronomical data to find an unknown planet. An enormous mass of data is first arranged to determine that some bodies seem to move in orbits among the stars. On closer study it appears that these orbits show some erratic effects, and areas are identified in which these effects seem most likely to occur. These effects are then examined from all angles to see if a reason for them can be surmised. A variety of tentative conclusions are made and tested against other known facts, and the location of a new planet involves a third or fourth derivative of the original orbit.

The perturbation-analysis approach examines who is saying what, and why, and goes beyond this to consider the reasons for the bias of different experts. It is a direct opposite in this sense of the Delphi approach, which masks differences in anonymity in order to arrive at a consensus. In the Soviet study, pertinent conclusions directed attention to the lack of training in Soviet universities in what we call chemical engineering, but with the companion observation that work of the highest quality can result in areas of R/D that receive a high "national priority." Specific conclusions directed attention to areas which would be of probable interest to the USSR (as of 1970) in any future interchange with the U.S. in science and technology.

These principles were derived from the analysis of subjective observations. They have since been tested and in general confirmed by subsequent experience. The basic technique is to select an area of information for careful scrutiny, based on preliminary correlations, to predict the nature of a variable and where to look for it. This correlation can then be checked against what may be very fragmentary data at a specific point, for further refinement.

The application of the perturbation technique to the present study involved an aggressive search for areas of agreement and disagreement among the experts interviewed. The object was to detect and define significant variables in their criteria for the selection of an information service. As this approach was confirmed, it became standard practice to (1) ask each expert to identify others whom he would expect to disagree with his statement of priorities, then (2) go to these or others like them, and (3) work out between the two a statement of variables and definitions acceptable to both, to describe the differences in their points of view. The emphasis on examining reasons for individual value systems requires a continual awareness of the personal bias of the investigator and the special environment of the study. The awareness of these hazards helps to avoid their effects, and it is also helpful in interviews continually to seek for areas of disagreement or divergent viewpoints.

The special environment of much of this study is a corporate research laboratory where in-house information services are highly valued, and are provided as a corporate-service function to all professional employees. The effects of this bias are recognized herein as an explanation for some of the statistics obtained, and also for differences from selected interviews with the managers of a variety of information service operations

at other locations. An example of personal bias is the tendency to draw generalizations, which must be guarded against as a hazard of ambiguity in the results, or hidden constraints. For this reason, the conclusions drawn herein are concepts to be considered as a skeleton for the organization of ideas -- as a guide rather than a directory.

Dimensional Analysis

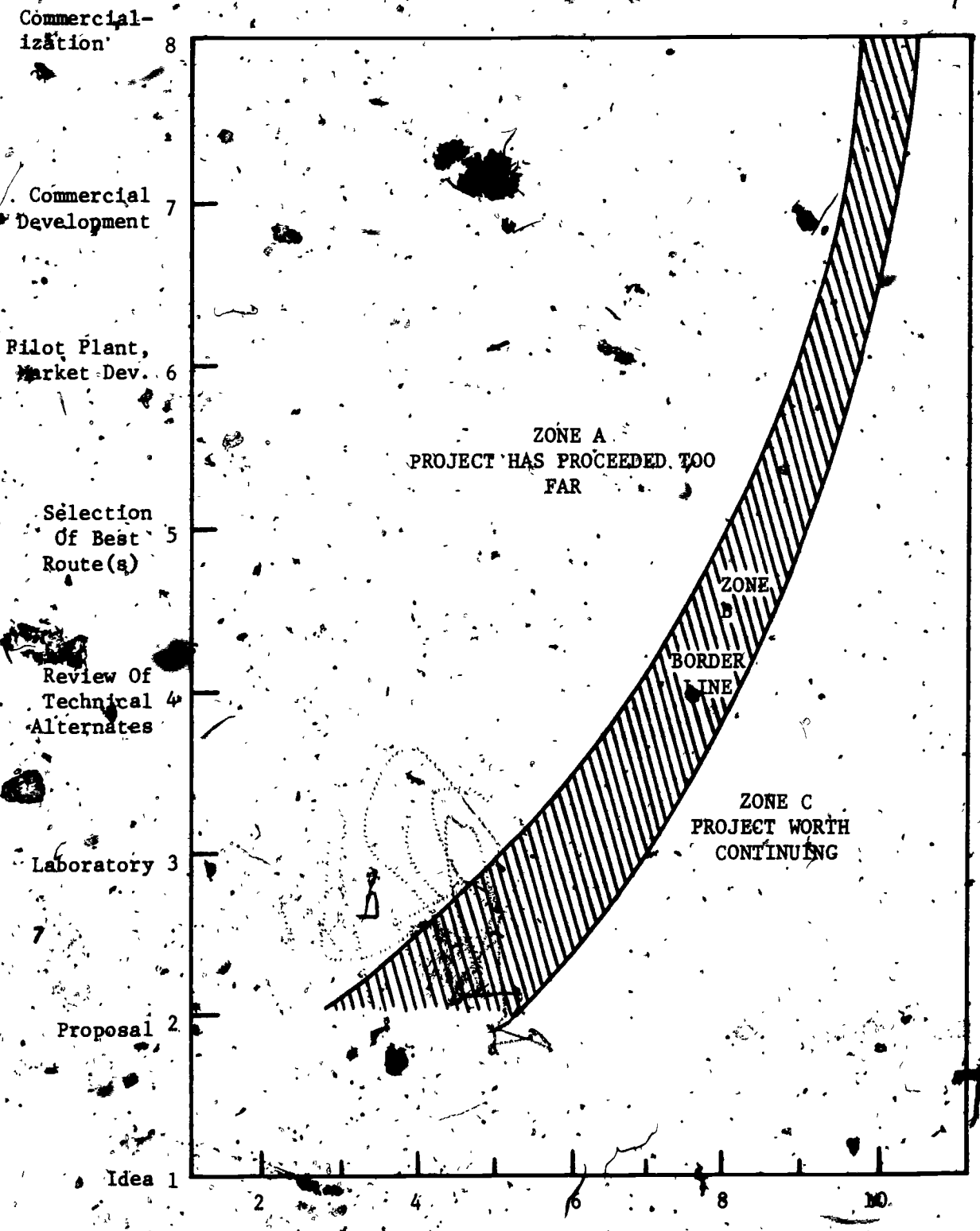
Business literature on the evaluation of research goes back for several decades. Efforts to relate the value of research to ordinary business parameters alone (such as DCF) have shown that this approach sacrifices entirely too much regarding the value or probability of a different outcome. Improved systems for the analysis of uncertainties find some means to include and to operate on subjective evaluations. In a one-dimensional analysis, uncertainty factors and numerical factors such as cost/benefit aspects are frequently entwined, and it is necessary to resolve them.

The dimensional approach to the analysis of complex variables in project evaluation was advanced 15 years ago for the rational selection between projects in industrial research. Harris (Monsanto) described a profile scheme with 5 "aspects" as headings for 26 factors, each ranked on a four-unit scale from very good to very bad (16). This system for the evaluation of research was not widely adopted, and later studies suggested that 5 major headings is still too cumbersome. A more limited number of dimensions is preferred (17). Three dimensions has this advantage and is the minimum required to escape the hazard of "Flatland": false cause and effect conclusions from two-dimensional thinking regularly assume that if a thing is not black, it must be white, forgetting all about red or green (18).

Systems of this general type have been tested extensively for use in research planning and the evaluation of projects. One key to success is to be able to break the analysis down into a small number of discrete chunks that are analyzable segments that can be examined separately. One such system to rate the "value of an idea" in R/D chose the three headings of novelty, potential value, and ability to commercialize, with suitable subheadings under each such as patentability, technical uniqueness, or commercial novelty. Ratings for each factor were a subjective ranking of value judgments, in terms of probability or extent. Each main heading was then rated as an average of the subheadings rated separately. A number of in-house research projects were rated in this way, and were compared with a numerical rating of the final stage reached in their development toward a commercial success. A plot of these data, in Figure A-1, shows a clear correlation between Idea Value and the development stage attained. It is significant that parallel ratings by independent panels of experts who were equally qualified showed check results which were remarkably close, within a few percent on a numerical average of ratings. The extent of this agreement was reported with some surprise, as it had been by Harris and others before, since it was assumed that subjective ratings would be inherently less consistent than those based on physical data.

Figure A-1

Relationship Between Idea Value and Development Stage



The dimensional approach makes no effort to compile exhaustive check lists of variables, so the sub-headings in the text Tables 1, 2, and 3 above are all typical, not complete. The principle is that the same amount of effort is more productive when it is spent in looking at things from as many viewpoints as are necessary to establish perspective. It is the differences in the viewpoints which are represented in the summary Matrix of variables and interaction effects.

The particular dimensions chosen in this study to reflect the value systems of different users received a direct input from behavioral analysis. They are taken directly from the Jungian system of psychology, which considers the objective/rational, subjective/qualitative and judgmental/intuitive aspects and their interactions with the environment as fundamental characteristics of behavior. These patterns of behavior help explain why the scientist or engineer is so baffled when management says "No" to a well-planned project, and equally why the rational planner can expect his system to be all things to all people if only he can get them to absorb the necessary costs.

Overlapping New Technologies

The simultaneous development of different new methods of access to information confronts the user with an uncomfortable choice as to which tools to buy, and which buttons to push. It overlaps significant user-desired improvements in the older familiar systems, some of which the user himself may have helped create.

Science and technology have now reached the 4th or 5th generation of information access tools, with new tools coming on so rapidly that the lines between generations are blurred. A host of special services of every imaginable type are superimposed on journals, abstract journals, indexes to abstracts, and computer access to indexes. The design of new systems and services is itself a well-established discipline, so that the availability of new technology is less and less of a limit. The number of information services available is in the thousands and still growing, and each of them has been created to meet the challenge of specific user needs.

Current statistics on the growth of information services amply support these indications. The number of "abstracting and indexing services" listed in Ulrich's International Periodicals Directory has grown to about 1250 in 1975 from 1200 in 1973, up from an estimate of 300 in 1950. The number of "information service centers" listed in Kruzas (International) Encyclopedia of Information Systems and Services rose to 1750 in 1974 (2nd Edition), an increase of over 100% since 1971. The number of computer data bases available for scientific information was about 88 as of mid-year 1976, 57 in 1975, and 30 in 1974, doubling every 1 to 2 years (19). The same trends appeared earlier in the NSF "Guide to Non-conventional Scientific and Technical Information Systems in Current Use" from 1958 to 1966, when the number of mechanical sorting systems in use showed a doubling period of four years (e.g., edge punched, tabulating cards, peek-a-boo systems). This rapid growth was all but obliterated by computer systems which increased at a sustained doubling rate of less than two years, from 17 in 1962 to 118 in 1966 (out of 175 non-conventional systems reported).

The cumulative effect of these statistics is indicated in Table A-1. The rapid growth of the scientific literature, abstract journals and more sophisticated electronic methods of access to information was cited as a classic example of the "Diseases of Science" in a remarkably predictive essay in 1961 by deSolla Price. The growth of technology and science leads to new technologies, and each new generation in a given field of knowledge tends to grow faster (20).

Price discusses growth curves of three types. The normal growth pattern in nature is the S-shaped symmetrical logistic curve, where the supply of food or some other resource is limiting. [illegible] growth rises rapidly at first, has a nearly linear middle portio[illegible]r a few doubling periods in time, and then levels off just as rapidl[illegible] it runs into a shortage of food, water, or some other basic resource. The usual end result unless there is some new supply is that the whole system collapses. This applies to the normal growth of bacteria in a culture, fruit flies in a bottle, or jack-rabbits in Australia.

The growth pattern for the number of scientific journals has been strikingly different, with a doubling period of fifteen years which has been nearly constant for 16 doublings over 250 years, from the first few journals to a hundred thousand. This is a straight line semi-log plot. Price finds the same pattern for the growth of abstract journals which started when the number of primary journals exceeded 300, or more than one man could read.

The semi-log plot of the growth of scientific journals and abstracts has too often been quoted out of context, ignoring Price's main point. Continued linear growth may apply to money at compound interest but even there it collapses if the bank fails, and it ceases if the interest is withdrawn. An unlimited supply of all necessary resources must include time, money, and social values as well as food or air or water or new information. Free access to all of these is an illusion: a constant linear doubling rate for the total number of universities or scientific journals or information services can continue "indefinitely" for only so long as society is willing or able to allow unlimited access to time, money and all of the facilities required. The difference between the linear and logistic curves is very well illustrated by the difference between theoretical and actual returns for a chain letter, as it runs out of gullible victims. If there is no means by which supplies can be replenished, growth goes negative and the system dies. The fallacy of the chain letter applies ultimately to every situation which assumes continued exponential growth.

Even more instructive is the fact that the growth of new technology in a given field leads to families of growth curves which grow at an ever increasing rate. The reason for this is that each related new technology benefits from the tools and experience of the ones before it. Price illustrates this with the growth rate of the total number of scientists which doubled in the United States over the past 200 years about once every ten years, compared to a 300-year average doubling period in Western Europe of 15 years. The doubling time in Russia since 1918 has been more rapid, about once every 7 years, and in China from 1940 to 1960 it was even faster, doubling every 5 years. He applies exactly the same principle to the growth of new technologies for access to scientific information.

Table A-1

4 Generations of Information Processing

Information Process or Service	Information Provided	Doubling Time Years	Doubling Time (Period)	Current Comment
Access Tools				
Scientific journals	Original data	15*	(1750-1970)	apparently slowing down (controversial)*
Abstracts and indexes	Reference + content	12*	(1875-1975)	1950-75 close to 1875-1950
Mechanized indexes	Index to abstracts	4	(1958-1966)	growth overwhelmed by computers
Electronic sorting, computer data bases	Index to references; interactive searching	1.6 1.2	(1958-1966) (1970-1976)	data bases in 70's computer systems in 60's
Information Service Centers				
Searching and retrieval (with or without analysis)	Any of the above	3	(1971-1974)	services and centers total over 3000 (1976)

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* Constant doubling times assume a vanishing border line between science plus technology and other bodies of information.

The chart which Price uses to illustrate the effect of increasing growth rates in such a family of technologies has been modified slightly in Figure A-2, to fit the data given in Table A-1. The only difference is that in his family of curves on the number of scientists it was the 4th curve for China where growth was truncated by a cultural revolution. In the growth of information services it is the intermediate curve for mechanized index systems where growth was overwhelmed by a younger generation. The computer systems which Price referred to as "electronic sorting" in 1961 doubled in less than 2 years during the '60s, and this same rate of growth is continuing into the 70's in the phenomenal increase in the number of data bases available. The growth of information service centers fits the same family of curves. It uses all the tools available, and its doubling rate of 3 years is exceeded only by that of the computer data bases, the newest generation.

The doubling period for the number of abstracts and indexing services is only slightly shorter than for scientific journals, and Price drew them as of 1950 as parallel lines on his semi-log plot. His plot is reproduced in Figure A-3 with the addition of the recent data as a double point at 1200/1250 for the years 1973/75. This extrapolates as a straight line continuing the slope of the original data for 1875 to 1940. The first half dozen entries for abstract journals appear off the curve as precursors, for the same reasons as cited by Price for the first few scientific journals. They are properly omitted in determining the statistical slope of the line.

No firm data are available as to whether the number of scientific journals as of 1975 is anywhere near the 400,000 which would be predicted by a continued linear extrapolation. The question is considered controversial, and an answer is beyond the scope of this report. Whatever overall data one accepts, there is clear evidence that by 1960 to 1974 the rate of growth in the United States was significantly below that for the rest of the world (21). The question of what is a "scientific journal" becomes more and more difficult to define as the borders of science expand farther into society. It might be agreed, for example, that Popular Science Magazine is a journal of technology, if not of science. It is not so easy to decide whether to count either popular magazines or more serious journals devoted to parapsychology, astrology, or the mysteries of the pyramids. It is no easier to decide just where to stop counting the abstract journals. Such ambiguities cannot be avoided if the extrapolation is continued toward the point where there is one "scientific journal" or more per capita. Other results which Price predicted have become surprisingly real: the costs of each new technology tend to increase as the square or the cube of the number of men involved; the printed paper may be doomed, unless we can get even better methods for "abstracting the abstracts;" and the most persistent need may be a national science policy to set consistent goals for the effective use of technical information. The gradual disappearance of printed papers and the emergence of electronic data centers for every man, woman and child do not seem nearly so remote now as they did in 1961. The final prediction is that whatever new technology comes next, it can only be expected to grow faster, and have a still shorter time before it has used up its share of all the resources society will allow for the growth of science.

Figure A-2

Growth Rates in Science and Technology

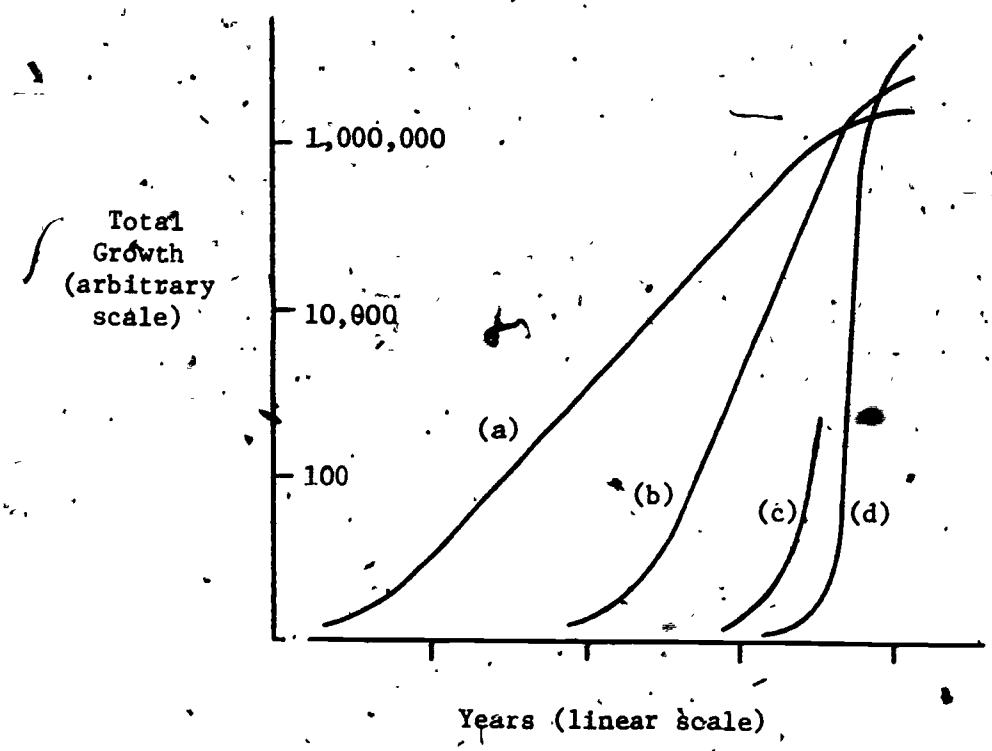
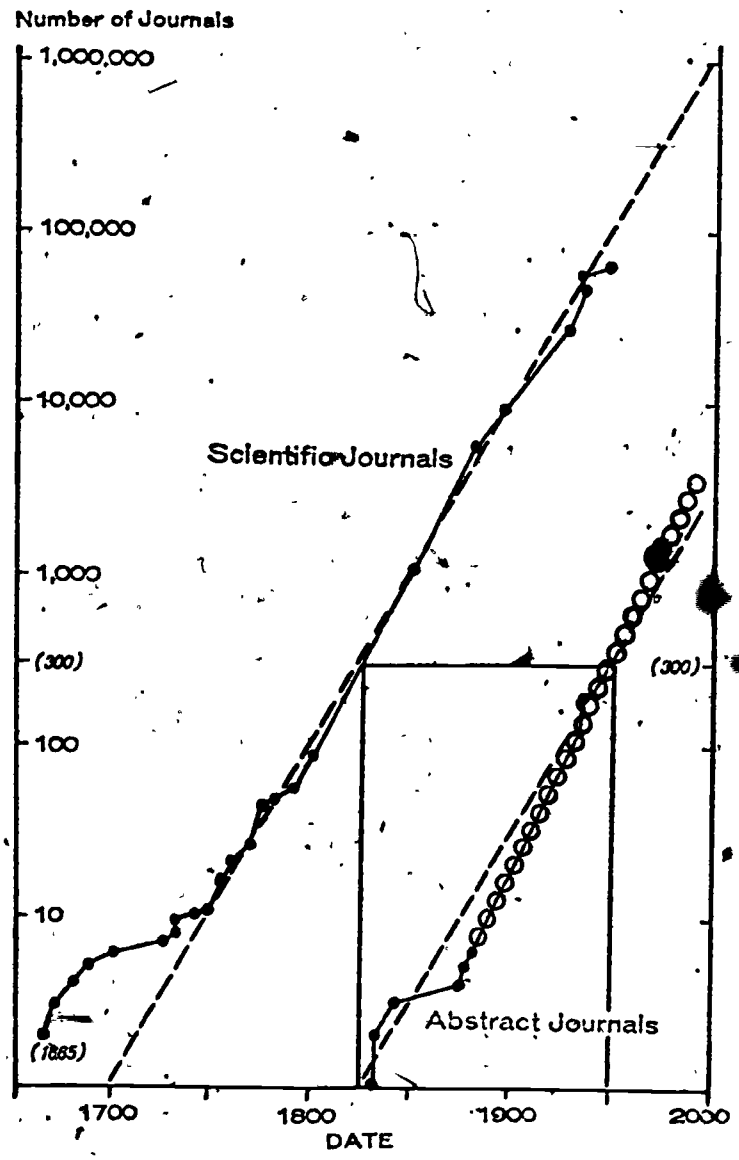


Figure A-3

Growth Rates of Journals and Abstract Journals



What Will Be Actually Used?

The designers and vendors of information services would like to assume that major improvements in the services they offer would find new customers. But the total market expands only slowly at best, and compared to the rapid growth of new services it can be considered as almost a constant. To this extent, any increase in the amounts of time and money which the users of STI devote to purchased information services will be taken away from other functions, such as laboratory research and development. For one service to expand it must take business away from others, and the vendor finds himself competing with his own established lines for the same customers.

Intense competition places the emphasis on what service is actually used, not what looks useful. Even the best of services can go out of business under adverse economic conditions, as happened to Chemisches Zentralblatt and British Chemical Abstracts in postwar Germany and England. A more common occurrence is for a new newsletter or special journal to fail to find enough customers to survive, regardless of high quality in the first few issues. Technical society journals benefit from having a guaranteed market, and generally improved communications in both directions. Thus, a close response to the needs and wishes of its customers has been a major factor in the success of the Chemical Abstracts Service, created by chemists for chemists.

The problem of original source documents which are not available for abstracts in print may be partly a question of who wants what. Data from a brief statistical review based on the Chemical Abstracts Service Source Index for the years 1973-74 indicate that this occurs often enough to be a problem, with sources cited from behind the Iron Curtain. Larson has stated that 7% of all the sources indexed are not available in the U.S. (22). Many of these are sources cited no more than once a year. A random sampling and identification was made of the sources cited on 50 pages out of the 2000 in CASSI. For this sample, one fourth of the sources "not available in the U.S." could be found in other libraries listed, but three fourths of them are not available anywhere in the free world.

A further analysis of this sample is being made with the cooperation of Chemical Abstracts Service. One assumption which can be made depends upon the fact that the professional searchers who are most likely to talk to CAS are often willing to accept references in their reports by title only, or title plus abstract. The scientist or other researcher who wants the original document is a step removed from this direct contact. When he fails to get what he needs, his sense of frustration is directed primarily at the librarian and may stop there. Such a reference is of negative value to the customer, not zero value, since it wastes more time and effort every time a potential user finds it interesting. One approach has been to question the practice of even having an abstract which may have been translated from Referativnyi Zhurnal, when it proves impossible to get more information. A simpler recommendation to save this annoyance and expense would be to place some definite marking in the abstract or index whenever it is known that the original is not available. This could provide the citation for what it is worth, without the frustration of trying to find more.

The quantity factor in the demand for information services has probably been distorted in recent years by subsidized government requests for "all the information available" on a given subject. The effect of these open-ended requests is hard to place in proper perspective. Government agencies had the first computerized index systems, in such places as the U.S. Patent Office, NASA, and the Department of Defense. Civilian agencies were invited to bid for government contracts to assist in evaluating the information available in these files. Many subsidized contracts of this type were let by the Environmental Protection Agency and other branches of government. Their purpose was to evaluate the information collected for publications on criteria for standard setting, or the best control techniques available for potential pollutants in air or water. Other subsidized requests were simply bibliographic at first, to load potential source material into the files.

As the number of these subsidized requests increased, more users became involved, and the information tools available for them were continually improved. The literature review for a 1 to 2 year project might be completed in two to six weeks, with a large number of references but no extra time for their evaluation. Direct subsidies for simple bibliographic compilations have become unusual, and the same thing will presumably happen to the demand for published compendiums of all the information available on a special topic. The distortion comes about when it becomes progressively easier to produce references in any quantity desired, without requiring that they be digested or used.

The quality factor in the growth of services into new market areas has a different set of limits. These can be illustrated by referring to Prices' chart on families of new technology, in Appendix Figure A-2. The competition between overlapping new technologies means that most of the market for the youngest generation will ordinarily be subtracted from the business available to its predecessors. A rapid new development may break through the previous limits to growth into a new market area, above the earlier curve, only when it can draw upon some new resource not previously available. One example of such a new resource is the high speed of computerized searching, coupled with multiple uses for the same user training and facilities. The trouble is that this may come at the expense of other parts of scientific research, not in addition to it. It is too soon to tell whether the enormous amounts of information poured into official requirements for environmental impact statements or best available technology [illegible] to the total amount of time and money devoted to science and technology. [illegible]he moment it appears that until they are completed, they are displacing [illegible] aspects of research and development.

The interactions of new technology and its potential users can be very disappointing. Two cogent statements of basic principle in this area have been made which are entirely negative:

> Mooer's Law: an information retrieval system will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it (23).

Zipf's Law, as modified by Allen: statistical analysis of the choice of information channels shows a direct relationship to ease of access, with far less attention to the effective use of time, and no correlation between perceived technical quality and frequency of use (13).

Mooer's Law can be considered as a modern paraphrase of the old maxim "Where ignorance is bliss, 'tis folly to be wise," and both of these statements are related to Zipf's original studies on "The Principle of Least Effort" (24,25). Allen's study of the information source-selecting criteria of electrical engineers at MIT is being updated in a new edition, which reaches the same basic conclusions. Others have reached the inference that "the ease of use of an information gathering method is more important than the amount of information expected" (26,27).

The rapid growth of technology superimposes upon this negative attitude the fact that constant training is required to use the newest tools to advantage. The information intermediary has an increasingly important function in liaison between the service and its potential user-customers. This is one element in the question; will it be used? Does the customer want to use it, does he know how to use it, does he need help to use it? (28) "Information broker" is the new word for 1976, and additional new titles can be expected as this function becomes more complex. Repeated efforts to train the customer himself to use the more sophisticated services have suggested that the person most likely to look for help is the experienced customer, who knows the value of information. No matter how much or how little such training the scientist may have, the information expert has more.

The inherent conflict between quantity and quality of information is made worse by this division of effort. The technical function of producing references is the work of a specialist, and the evaluation of information is the job of somebody else. New technology produces a large increase in the quantity of information to be processed. Without an intermediary, it is the customer's time which must be used to reject the trash before the "information" produced can be used. The quantitative selection is by pertinence or relevance, not by "value." The threat is that bad data will push out the good. This tends to repress the accepted value of any single fact, and if ten bits of information are not enough, it is possible to produce a thousand. To meet this threat, it is vital to recognize that both the operating function which produces the information and the research or planning functions which use it are necessary and independent. Neither can function properly alone.

APPENDIX B

DEVELOPMENT

Proposal Postulates

Throughout this project, the identification of variables considered as significant by different users in their selection of information services has been based on one-to-one interviews in the field. The survey and its developing conclusions were discussed with each person on the average two or three times during the year, for periods of about 5 to 30 minutes. The object was to recognize and discuss the working bias of each user interviewed, give full acceptance to its validity, and thereby establish it as data for a generalized approach.

Several postulates to be examined were set forth in the proposal for Contract C-1027. Others were developed during the project. The following initial postulates were drawn, based on several decades of experience in information research:

- There are identifiable groups of users of information services who differ from each other in their basis for selections between competing services;
- The examination of different points of view can be far more productive in the analysis of an information problem than an exhaustive study of any one viewpoint;
- The many factors used for comparisons between services are interrelated, and principles can be found by which they interact for different categories of users and different types of services.
- Statements on the relative values of information services in the literature or elsewhere must be considered in the light of who says what, and when;
- The consideration of who says what is in one sense a direct opposite of the "Delphi approach" which masks personal differences in anonymity, on the assumption that a statistical consensus is more useful.

Initial Interviews

The first interviews were conducted with individuals who spend from 50% to 100% of their time in the use of information services, to look for areas of agreement and disagreement in how they select which service to use. These interviews addressed two questions: (1) What specific abstracting/indexing services do you find most useful, in your daily work?" and (2) "What discriminating factors would you recommend in telling someone how to choose between them?"

Four full-time searchers were interviewed, spearately and together; their conclusions were in good agreement, as summarized in Table B-1. Counting related publications by a given publisher as a single source, they named a half-dozen services as "unique" for their use, not replaceable by anything else. The second column in this table shows the discriminating factors they selected as the basis for comparisons. These were used as column headings to expand the table into a grid, with entries for each service listed.

No attempt was made to expand the obvious heading of "specific fields covered." Upon further consideration this variable, important as it is, was excluded from the study by definition: if there is only one service covering a given field it gets all the business there is, because there is no competition. If there is competition, the choice is based on other factors (completeness, quality, etc.) and not just on the field of coverage.

The column for cost was left largely blank in filling out this grid, even by the most experienced searchers. They referred to the staff administrator in charge of budget for more accurate information. The same thing happened repeatedly in other interviews whenever costs were mentioned. While cost is a factor in initial-purchase decisions, the choices that turn out well seem to involve an essential component of experience or the manager's hunch. Once the service has been purchased and on the shelves, its purchase cost is no longer considered as regards day-to-day use. Operating costs become a larger variable, and it soon became apparent that cost is a factor that is commonly deferred to someone in management. A number of the discriminating factors named are related to physical facilities, space, and the time required to keep the service usable. These are all budget items, related to indirect costs.

In developing Table B-1 it became apparent that the variables listed as column headings deal with quantifiable factors, while quality factors tend to appear in the comments. The deferral of part of the decision to management was interpreted at first as based on costs and budgets, but conferences with various managers emphasized a strong experiential component in management decisions. A typical statement was: "If I were considering a service where I had no experience, I would try to find another manager whom I could trust, who did have some experience I could consult." Behavioral analyst consultants helped identify this 3rd dimension as the judgmental/intuitive aspect in the decision process. This aspect is characteristic of management, but is by no means so limited.

The "bases for comparison" in Table B-1 were next expanded to a table of factors grouped in the 3 dimensions named. One draft of this is shown in Table B-2. The lines between categories are not always sharp, since there are some factors which can go in more than one place, but the pattern can be clearly recognized. This Table B-2 was next shown to several scientists who are frequent customers for information searches and other services. They agreed on the significance of the factors and dimensions named, but disagreed on their relative importance. The scientists all said that they would put qualitative factors first in their selection; "Which service is a pleasure to use?", and pay relatively little attention to the quantity factors as a group.

TABLE B-1

DISCRIMINATING FACTORS APPLIED (4 USERS)

"Unique" Services, Most Used	Bases for Comparison
Chemical Abstracts	Fields covered
Index Hard Copy Text Microfilm	Cost $/yr Shelf space/yr
Derwent - C.P.I.	Timeliness: text + index
API - Abstracts:	User requirements
Patents and Literature	training skill
Science Citation Index	Minimum use required
	Maintenance time
Predicasts,	Comments
CMA, Funk-Scott	
Engineering Index	
Applied Science and Technology Index	

TABLE B-2

FACTORS IN SELECTION BETWEEN COMPETING SERVICES

Dimensions in the Selection Process:

(a) quantitative factors
= numerical (objective)

- cost factors, (for first look or continued use)
- coverage of selected fields
  - completeness (no. of documents in field)
  - (% of available literature in field).
- time factors for delivery
  (soonest and latest, as well as average)

(b) qualitative factors:
= rankings (includes subjective)

- format of report
  - appearance
  - orderly presentation
  - convenient access within report, indexes, arrangement
- flexibility of coverage
  - ability to vary (+ select) depth of coverage, details
  - ability to highlight selected items by closeness of match to question
- responsiveness
  - can it change priorities
  - add new items on request
  - tolerate ambiguities
  - will suit "our way of doing things"
- feedback
  - communication with or by user
  - to redefine question during search
  - suitability for browsing

(c) business judgment:
= go/no-go (includes intuitive)

- reputation
  - recommendation of past users
  - reliability, uniformity of quality
  - confidentiality
  - viability, will it last?
  - familiarity, to improve efficiency
- factuality
  - if he says a thing is so, does he have a basis for it?
- consistency
  - recognized dependable bias
- experience in actual type of work involved (not just the field)
  - skill to anticipate problems
  - optimization of procedures

The three-dimensional outline and the headings in Table B-1 were next checked independently with the managers of two outside information centers -- a pharmaceutical research library and a university science library. They confirmed the headings selected and the same list of services. They recommended the BIOSIS and Medlars/Medline services as "unique" in their field (replacing the API abstracts) with the [illegible]tation that initial training time and regular continued practise are essential to maintain the minimum skills required for their effective use. Overall, the lists of services and discriminating factors obtained independently from these interviews showed a high degree of agreement, with minor differences in the order for specific individuals.

In an attempt to generalize why this agreement was realized, it appears that these are services where the same amount of basic training, experience, and facilities makes it possible to answer more different types of questions than a competing service, which is rated less valuable. A different conclusion based on the same data could be that because these services are used more often, the users became more skilled in them and find them easier to use. This is not necessarily a different conclusion, however, since both may be related to the observation that this service is more flexible, for more users.

No such agreement appeared in efforts to prepare a broader list of this type for the same users, to rank the 30 to 50 abstracting/indexing services they consider most useful: titles and rankings beyond the few in Table B-1 were completely different for each user/searcher, or for the same searcher for different searches. This suggested a further analysis of the data to consider what types of questions get the widest fluctuations from one worker or one use to another, and what questions are most likely to give a better matching of answers. The "unique" list was probably a good question on this basis, and the second list was not. The failure of this effort led to a new direction in the study, to look for areas or circumstances of predictable agreement or disagreement in the basis of selections. Stated differently, the important variable is not just the user as an individual, but a combination of user characteristics with the specific use at ha[illegible]

Perceived values in the importance of direct and indirect costs are an obvious area of disagreement. Subsequent interviews indicated that time is another variable with aspects which differ greatly in their relative importance to different users. There is a question of whose time is most valuable and when, what portions of the total information request the customer is willing to delegate at a given time to someone else, and how much of this work the customer prefers to do for himself, to become more familiar with the material. These were examined further as interaction effects which involve both the user and the environment of use.

User Population Groups

This confirmed the original strategy decision to examine as carefully as possible the nature and reasons for individual bias and report them anonymously at the end rather than concealing them throughout, so as to develop a fuller understanding of the decision-making process.

The review of areas of agreement and disagreement found in the initial interviews suggested a more detailed survey of usage patterns among the 15-20 regular users of information services at the Exxon Research and Engineering Central Library who spend some 50% or more of their average working day in searching the literature. A third of these are library staff, half of them information analysts or searchers who have special areas of interest, and others include scientists who are strongly oriented toward the use of the literature. All of these groups comprise individuals with different levels of training, skill, and responsibility - including the freedom to decide which searches are most worthwhile, and what information will actually be used.

The first step in the survey proposal was to conduct a preliminary interview with major users, based on their records of past experience, to determine what information services each one uses most and about how often. This was to decide what questions are worth asking, and what services should be added or removed from the previous lists for tabulation. Preliminary indications were that many users have one or two favorites, which this individual uses more than all other services put together, (e.g., CA, Derwent, API abstracts). The plan was to ask for a complete tally from each user for several weeks, with follow-up discussion, after eliminating for each individual as a convenience those services used most often (i.e., 50 to 90% of all uses). That is, the survey was to be simplified for each participant by identifying this pattern in the preliminary interview, confirming it, and concentrating thereafter on incremental uses of other services.

This set of preliminary interviews led directly to the identification of the "user populations" referred to above. At the time the survey was started, the distinction had been drawn between searchers, scientists, and information managers as user groups having different sets of priorities. Completion of the initial interviews identified the seven sub-groups of user populations discussed in the report, Table 2, and their differences in value priorities as reflected in Table 3. This filled out two elements in the Matrix proposed, and redirected attention to a closer study of the characteristics of the user groups and possible interaction effects between the type of user and the type of use. A more immediate problem was the question of acceptable definitions for user groups, and where to put the "manager" as a user of services.

Management Viewpoints

Improvements in the use of scientific and technical information constantly run into the limitation that the number of managers who are greatly interested in information systems and services remains about the same, regardless of the changes and improvements made. The original scope of work of this project and initial conferences with NSF emphasized the

importance of getting input from different managers and disseminating the results widely to the attention of managers outside of the information field itself. This proved to be a profitable approach.

The original outline of dimensions was discussed informally at the Engineering Foundation Conference on STI Services at Henniker, N.H. in August 1975, and expanded at the ASIS meeting at Boston in October 1975. Two important elements in the selection process were reported in numerous user interviews as being "deferred to manager": questions of relative cost (direct or indirect), and the preparation in advance of an approved list of services (based on costs or other factors). The operating "manager" was considered as a special user group, with additional functions such as project evaluations and the choice of a work environment.

A first draft of Table 3 on the priorities perceived for selection factors in different dimensions placed "managers" with "vendors" as a user population to whom costs come first, whereas "scientists" and "planning staff" put their emphasis on factors of quality and experience. This scheme was not satisfactory, since the manager's viewpoint can be just as clearly identified with planning staff as a major function. It was changed accordingly in an Interim Report (March 15, 1976) prepared as a popular presentation of the "Matrix of user values and interactions," to meet editorial suggestions by the editor of the ACS journal CHEMTECH. This article (29) was published in August 1976, addressed to a broad audience of project managers in chemical technology. It emphasized the impacts of growth in information technology (see Appendix A) and analogies between the selection of engineering services and information services.

The Matrix was expanded to include user impacts as an additional interaction effect, and was presented at the National Information Retrieval Conference in Philadelphia, in May 1976. Discussions with leading experts in the information literature at that time confirmed the dimensional analysis and matrix approach presented as valid and useful.

The presentation for NIRC was first previewed and approved by an Oversight Review Committee meeting at NSF the end of April 1976. Plans were also discussed at this review meeting for a questionnaire to expand the data base of replies from initial interviews. This had been designed for use in-hand, during follow-up interviews, to correct for the initial bias of replies obtained most easily from the "movers" who are most interested in new ideas (see Appendix C). During this discussion, particular emphasis was placed on the observation that the differences in value systems of different users would also appear differently to three different groups of managers. NSF directives following this discussion urged: (1) more attention to the differences between managers; this has been expanded as a major conclusion in the Executive Summary and Text Table 6, and (2) to test the proposed questionnaire on a larger sample, to examine the "value preferences" of different user populations. This test has been made, with procedures and results as summarized in Appendix C.

The viewpoints of different managers were explored further during 1976 in interviews with selected individuals at the ASIS mid-year meeting at Nashville in May, and at the Gordon Research Conference on Information Problems in Scientific Research in July, as well as at NIRC and the Oversight Review Meeting in April. The general trend of these comments has been worked into the discussion above (Text Table 6). The following are highlights of the comments of different managers consulted:

- Preference rankings in the value systems discussed are relative, not absolute: a low ranking does not imply zero value, but only that other values are considered more important.

- The fact that an item of information is new to the user may be enough for some (R/D planning, marketing) but not at all for others (patents, contract negotiations).

- User-impact interactions may have an effect on revisions in the management decision as to how much time can be devoted to looking at information rather than other work (such as the effect on user self-esteem of paying someone else to do thinking for you, rather than simply looking up facts).

- The balance between direct and indirect cost effects has a major interaction with time constraints, which differs with the type of user/manager and the environment of use.

- When service is satisfactory, credit values for the service as a whole may be much more easily recognized than "critical incident" values, which seem to cause conflict in claims for credit.

- A desirable end result of the present approach is a set of classifications by which people can find a home for their viewpoint, with segments from the user end rather than, as usual, from the manager or provider of the service.

- Individuality is difficult to promote in any bureaucratic system, and functions which require it are likely to be downgraded or unrecognized.

- Personal skills of individuals in the system are clearly recognized whenever special services for special customers are desired.

- Judgmental values are not well appreciated by the "rational man" who expects his system to be all things to all men, if only it can get enough support.

- Planning staff never has extra time, has access to patterns of decision not available to the scientist, and is more concerned with plausibility of a point of view, and means to evaluate it, than where it comes from; time means money.

- The university environment is very different from the industrial one, with cheaper labor and fewer time constraints, but strictly limited capital. Industrial systems are far more sensitive to time/labor costs, which depend strongly on whose time is being spent.

- A major management concern before purchase of a service is to be certain that different bases of decision have at least been recognized, and not overlooked because of a lack of extensive data.

Managers and User/Workers Agree in Function

On further study of the priority values of managers in field interviews, it gradually appeared that the word "manager" could be placed just as well one place as another in Table 3. Every user population includes manager/users as well as user/workers, and every user can be a bit of a manager. As the initial confusion was resolved, several conclusions appeared:

- Different groups of managers can be found, just as with other groups of users, who differ in the values they perceive for different factors in their selection of services.

- The difference lies in what the information service is being used for at the moment: the research function, the planning function, or information operations.

- Managers and user/workers involved in the same function share the same relative values for the priorities perceived, and the same set of meanings or connotations for the words used for key parameters in the selection process.

Accordingly, Table 3 was changed to refer to user function generically, rather than to specific user populations. Text Table 6 on the conflict in connotations for key words was developed to characterize the differences apparent to different managers. Here too, the same differences apply to both manager and worker for a given information service function. It is the function which controls, so the word "manager" was dropped from the caption of this table without changing its content. It may be noted that several of these words can still be accepted as terms in Text Table 1 (timeliness, time, depth), because their connotations in conflict all fall in one dimension. This is not true for the term "reliability" which was rejected as ambiguous, because it may refer to different factors in time (quantity), in uniformity (quality), or in reputation (judgmental).

The unifying character of this agreement in function is significant. The fact that the manager/users and user/workers see things the same way from this viewpoint appears to validate the concept of user functions, just as the disagreements and agreements on priorities of different user-populations appear to validate the concept of dimensions in selection factors. The skilled manager or any user applying management skills can apply the dimensional approach to identify areas in which he is strong and not so strong, and delegate or seek assistance in the weaker areas to improve cost effectiveness for the same total effort.

APPENDIX C

SURVEY QUESTIONNAIRE

Variables for Analysis

The analytical procedures and interview approach discussed in Appendix A and Appendix B led to an initial Matrix containing three variables and three interaction effects. These formed the basis for the survey questionnaire. The first variables outlined were the classification of selection factors into dimensions (see text Table 1), user populations into groups (text Table 2) and information services into types, as they interact with the user (see Definitions). The differences perceived were sharpened by the concept of priorities in user value systems as an interaction effect, characteristic of the user group (see text Table 3).

A second interaction effect characteristic of the type of service was identified as the personal impact of the user paying someone to do thinking for him, in information analysis as contrasted to more routine services. This was generalized to a desire to know and choose a specific individual, whenever the user is selecting an information service which he perceives as involving his own highest skills. This could be searching for the searcher, indexing for the indexer, or analysis for the analyst.

Differences and similarities were accentuated in the interviews by "perturbation analysis" (see Appendix A), asking each person who agreed with a given correlation to identify others who would either agree or disagree with his point of view. The next interviews sought to work out with both parties a suitable working vocabulary to identify the differences they perceived. A simple set of definitions acceptable to people who disagree on priorities and values is far from easy to achieve.

The next step was to examine each area where an interaction appears to exist, and try to find words to describe it. This identified a third interaction effect: user populations who agree in their ranking of priorities in selection factor value also tend to agree in the importance which they attach to having the originals of selected references in hand for their own use, rather than abstracts, titles only, or a digest review.

Further consideration of the procedures used to reach this stage suggested a danger that the results obtained could be influenced by subtle changes in phrasing the questions addressed to different user groups. Each interview for the analysis of variables covered the same general area, but the emphasis kept shifting as new correlations were found. This led to plans for a standard questionnaire to be used in hand for second-round interviews, to get a clearer view of the differences between groups when the same questions were asked in the same way.

Preliminary Design of Questionnaire

The first plan for a formal questionnaire was for a usage survey based on the concept of different priorities for different users (see text Table 3). This was to be addressed in-house to some 20 heavy users of information service, from different backgrounds (see Appendix B). The object was to examine the concept of priorities and look for other variables in the selection process. The table of priorities at this time listed the names of separate user groups, by specific discipline: scientist, engineer, patent attorney, searcher, information analyst, manager (as the one to whom cost decisions are deferred), vendor (as an author interested in data on cost effects). Comments on the concepts of selection-factor dimensions and user-value priorities had also been obtained from separate surveys of the users of a small special library, managers of information services at an outside conference, and the sources selected for 300 patent searches in special subject areas ordered by a group of patent attorneys over a period of 2 years.

Requirements proposed for the usage survey questionnaire were first to identify the user, in terms of discipline or user population at the time of a specific use event. This would be followed by a simple grid for each user with entries for each special event, and variables arranged as column headings to be checked for a subjective ranking of perceived importance. The format was to include six variables for each use or user: the three dimensions of selection factors, and the relative importance attached to recovering original documents, abstracts, or reference by title only. Additional variables might be added. The idea was to simplify record-keeping for each user by a preliminary interview covering these questions completely for those services which he used most of the time, and ask him to check the questionnaire only when for some special reason he used a different service.

This format was modified and not used after the preliminary interviews, because it was clear that it placed the emphasis in the wrong place (see Appendix B). There were repeated indications that the ranking of factors for the selection process depends upon the type of question or how the information is to be used, and not on the user's discipline. One such indication is how easy it is to design a loaded question which will make any desired one of a set of services look best, then ask other questions designed to completely reverse the order. This game can be played with any of the leading competitors, and it is a favorite ploy of the salesman for a new service.

The original postulate that usage patterns could be tied primarily to the individual was thus discarded. Further attempts to set up correlations with "service most used," subjective rankings, or field of interest were based more on studying the use at a given moment. Unfortunately, this complicates the problem of the definition of terms which do not mean exactly the same thing in one use as they do for another. This was identified as a cause of ambiguity in the statement of priorities for the "manager" and resolved when it was recognized that here, too, the controlling variable is not the person or his job title but his use for the service selected.

The questionnaire strategy was redesigned on this basis to develop a standard set of definitions for variables and priorities from the viewpoint of use rather than the user's discipline. The same set of propositions were to be presented in hand to the original cooperating set of 36 users for re-interviews, including any modifications made after their first comments. Personal impacts between the user and the service were added as an interaction effect for study, based on observations that the users of information analysis, patent attorneys, or planning staff want to select a searcher they know, even if he moves to a new firm.

An outline of the format proposed was presented and approved at the Oversight Review Committee meeting in April 1976, at the ninth month of the 1-year contract period. The Project Director and the Committee suggested that raw data of greater interest might be obtained in a limited time by sending the questionnaire to a larger sample of the populations available, instead of using it in-hand for re-interviews. This sample should also help to reduce the bias due to getting initial replies only from individuals known to be actively interested.

Final Draft

A draft of the questionnaire was discussed internally and reviewed with outside experts at NIRC in May, with particulate attention to questions in the dimension of budget/costs. A second draft was prepared and presented informally to individuals and interested groups at the Midyear ASIS meeting at Nashville. A number of suggestions on principles and methods of correlation were received from operating managers who had conducted user surveys at Battelle, Rand, and Rutgers. A helpful line by line review was also conducted in a breakfast discussion with a group of students from Syracuse University.

These suggestions were combined into another draft and reviewed with a consulting behavioral analyst, who recommended a final check with 5 "guinea pig" critics to take the test without oral instructions. The results from this suggested the clarification of definitions and instructions at several points.

The final form of the questionnaire is attached hereto. This was deemed ready enough in this form for internal use, where the returns could be followed up easily by telephone. It was recognized that further changes in format would be desired if a similar questionnaire were to be used again. The form Q is in four pages, with contents as follows:

Page 1 - preamble with definition of terms, expanded after the "guinea pig" test to minimize misunderstandings.

- "anonymous" definition of user background
- frequency of use for three types of search request

Page 2 - frequency of use for specific named services

- ranking of selection factors and costs for named services known to the user

Page 3 - relative importance of selection factors by types of use

- % of references wanted as originals, abstracts, title only
- opinion check list on personal impacts and preferences

Page 4 - open-ended questions, to help counteract the problem of forced definitions and ambiguities

Questionnaire returns show 100% replies to the identification question 1, 78% provided the optional signature, and only two persons removed the mailing label for an anonymous reply. The most effective questions for statistical review were the frequency check lists in 2, 3, 5b, and the specific preference list in question 6. The two questions 4 and 5a on the relative rankings of selection factors were too complex and read differently by different respondents. The concepts of text Table 6 were developed from this experience, to clarify the importance of the functions identified and their different characteristic connotations for the same key words.

The open-ended questions on page 4 received an 85% response, and over half of these replies provided some detailed comment.

Procedure and Initial Results

The sample chosen as the basis for test was a random list of 240 named individuals picked from the professional employees at Exxon Research and Engineering Company. In this sample 130 individuals were located at the engineering research center, 90 in laboratory research and 20 in smaller groups such as information specialists or patents. These sub-sets represent 10-20% of the employees sampled. The list was then checked or a telephone call was made to ask: have you during the past full year (1975-1976) done any searching in the published literature apart from reading current journals, either yourself or by asking someone else to conduct a search for you? The questionnaire was sent to a total of 89 who were known as users or who thus identified themselves. Response to the form took an average of 15 minutes.

The initial query showed that 49 of the 130 engineers used available literature services to search for information during the year, versus 81 who searched only in company sources or current journals. The same ratio for research was 40 to 50, or nearer 1 to 1. The list of 89 "known users" amounts to 40% of the total random sample of 220 from these two locations. This means that the other 60% of the test sample do not consider these information services as important to them. They satisfy their information needs in other ways, i.e., from original journals, company sources, or their colleagues in the invisible college, as indiciated elsewhere (13,30).

Table C-1

Questionnaire Returns (Raw Data)

	Engineers	Research
Total Sample	130	90
used literature services, 1975/76	49	40
not used during 1975/76	81	50
Questionnaires Returned	33/49	38/40
Number of Searches Requested		
0-1	19	13
2-3	5	8
4+	9	15
Number of Services Specified		
0-1	17	10
2-3	9	15
4+	7	13
Ranking of Selection Factors (replies)	(29)	(30)
quality/reputation/costs	23	26
all equal	4	3
costs first	2	1
Prefer Originals to Abstracts (or reverse)		
for R/D	+3,-15	+12,-9
for reports	-4	+1,-8
for decision	+1,-5	-5
Perceived values (average)		
know the individual	-.24	+.33
use known service	-.06	+.30
know approximate costs	+.25	+.06
compare on exact costs	-.72	-.67
computer-customer training	-.76	-.77
accuracy > completeness	.53	.41
prompt key references	.79	.91
Open-ended comments		
total	30	30
detailed	17	16

The greater interest of the researchers in information services is reflected in responses received, which was 38 out of 40 from research versus 32 out of 49 from engineering. Similar trends appear in the average number of searches made during the year, which was about 2 for the engineers and over 4 for research. The same applies to familiarity with different information services; a check list by title of those used at least once during this period showed an average of one for the engineers, and three or more for research.

A preliminary table of questionnaire returns is given in Table C-1. These are presented as raw data, since Contract C-1027 required only that a questionnaire be prepared suitable for testing and allowed no time or funds for statistical analysis. The arbitrary distinction between "engineers" at the engineering center location and "research" at the research center shows a number of interesting correlations. Both groups agree that factors of quality (convenience) and judgment (reputation) are ranked as most important (4 or 3) in their selection of services, where time and cost factors were ranked as almost nil (1 or 0).

Different values perceived by these two groups were ranked on a 5-point scale (vital, yes, neutral, not needed, and prefer not). The algebraic average was strongly positive for research and negative for engineers on the use of originals versus abstracts, using known services, and asking a known individual to collect the information. Both groups agreed (90 vs. 80%) that it is important to get key references promptly, before any further search. Both ranked completeness in a search ahead of accuracy, the engineers a little more so. The strongest agreement was on two questions with heavily negative response and 10-20% of the total as "prefer not," for the importance of knowing exact dollar costs to compare services, and even more against expecting the user/customer himself to know how to do computer searching. The two groups responded equally well to the request for comments.

The preference for using abstracts rather than originals for purposes other than research was stronger than expected and it seemed to increase for uses further from research, for report writing or for decisions. This preference may reflect a local bias at this location, where an aggressive effort is made to provide good abstracts directed at material of company interest.

The differences observed between the user-habits of research scientists and engineers checks a survey of the same group of engineers made during a previous year, when 100% of the library requests received for literature references came from 41% of the engineers. Both research engineers and design engineers were included. Requests ranged from 25% of "light users" averaging 4 requests per year, to less than 1% of "heavy users" (5 men) averaging 5 requests per week. These are the "information gatekeepers," only 1 out of the 5 on senior staff. This indifference to the literature may be a factor in the Zipf-law results reported by Allen among electrical engineers at MIT. It should be noted again in this connection that in contrast to scientific journals and reports, the engineer does not typically expect to find answers to his problems in the published literature, and it is unusual to find engineering know-how in written form.

ATTACHMENT Q

Return To: Homer J. Hall
Govt. Research Labs
ERC-28, Rm. [illegible]109

USER EVALUATION OF INFORMATION SERVICES

(NATIONAL SCIENCE FOUNDATION CONTRACT C-1027)

This is a survey conducted for NSF on "Improvements in the Dissemination and Use of Scientific and Technical Information". Its aim is (a) to explore the value systems which users of information services apply in deciding which information services to buy or use and (b) to provide a guide for user selections, among the many competing services available. "Service" is defined herein as any means of access to the literature other than your own reading of journals or books. This may be an abstracting/indexing service, or the personal services of a literature searcher/analyst.

This questionnaire is addressed to a random sample of Exxon professionals at Linden and Florham Park who are known users of information services which the Company provides. Its purpose is to examine the basis upon which you ordinarily decide which service(s) you like best, for a specific use. Telephone enquires about this form are welcome; your answers can be given by phone, or by interview if you prefer (ERC x2555).

1. Your Division _____ Year employed by Exxon _____

   First college degree and year _____

2. During 1975-76, how often have you asked someone to carry out for you any kind of information search (estimate)?

	Number and Complexity of Searches		
Requested from (names)	for a specified fact, reference, or copy	for a question redefined during search	for a report to include analysis of information
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
(Transmitted suggestions)	(____)	(____)	(____)

Please enter on the last line above the approximate number of these searches where you were transmitting a request suggested by someone else.

3. During 1975-76, how often have you used yourself or asked someone to use for you a specific information service? Please add the names of other services not listed, which you particularly like and use.

0 = never
1 = at least once
2 = several times
3 = often (average once a week)
4 = daily (constant use)

	Frequency 0 1 2 3 4		Frequency 0 1 2 3 4
Chemical Abstracts		Air Pollution Abstracts	
API Abstracts		Applied Sci/Tech Index	
Derwent Patents		Current Contents	
Science Citation Index		Environment Abstracts	
Predicasts		Petroleum Abstracts	
Engineering Index		ERDA Energy Abstracts	
		NTIS/GRA Index	
Lockheed/Dialog			
Medlars/Medline			
SDC/Orbit			

4. How do you rate the services that you know in the above list (3), aside from the question of subject area? Please enter your list below, by name or number, and rate every factor for which you have an opinion, on a scale from 0 = poor; 1 = uncertain; 2 = satisfactory; 3 = good; to 4 = excellent.

Service (by name or number)	Quality Factors: format	easy to use	responds to my needs	accurate	Budget Factors: cost efficiency	speed of response	breadth of coverage	Judgment Factors: present reputation	future prospects	Column (10) *
1. Chemical Abstracts										
2. API										

* Please enter in Column 10 (a) your estimate of how much this service costs, per year, and (b) other reasons why you particularly like or do not like this one. (use footnotes as needed).

5. What factors are most important to you in deciding what information service(s) to use? Since this may vary with your intended use, please specify this, and indicate for each type of search which factors you rank as most important in your selection of services (on a scale 0 to 4, zero to vital). Consider all quality factors as a group, all budget factors, and all judgment factors, as separate dimensions in the selection process:

Type of Search		Relative importance (0,1,2,3,4) of factors in selecting a service for this use:			Usual % of references you want to see, as		
information search for	intended use*	quality (convenience)	budget (costs)	judgment (reputation)	originals	abstracts	title/ author
a specified fact, reference							
patent information							
state of the art review							
browsing, general background							
project selection							

* specify, as use for R/D (planning results); report (writing); client (for sending to someone); decision (management); other

6. In your evaluation of information services, how important is it in your opinion to

	-- (prefer not)	- (not needed)	o (neutral)	+ (yes)	++ (vital)
know the individual who will do the searching					
use a service I have used before					
know myself how to do computer searching					
know approximate costs (order of magnitude)					
know exact dollar costs for comparing services					
rank accuracy ahead of completeness of coverage					
get key references promptly, before the final report					

Other + or - factors which seem significant to me include:

What effect does it have on you if a service which gives good results is

expensive?

or, hard to use?

of uncertain reputation?

contains hidden errors?

Why do you think people particularly like to use or avoid certain types of information services?

This survey of user values systems is in no way a reflection on the information services supplied by ERIC/CAPS. Thank you for your time and interest. It will help if you sign, but if you don't want to, leave it off.

Signed _____ (optional)

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12. Sponsoring Organization Name and Address National Science Foundation Division of Science Information Washington, DC 20550			13. Type of Report & Period Covered Final Report June 30, 1975-Sept 30, 1976 14.
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16. Abstracts The value systems by which the users of purchased information services select which one to use or buy are found to differ sharply between different user populations, but the variable found to control is the function of use, not the user as an individual. Selection variables are summarized in a Matrix of user values and interaction effects. The research function user (scientist, engineer, attorney) prefers original documents, and tends to choose subjectively. The operating manager (or searcher) more often stops with abstracts and emphasizes quantifiable factors. The planning manager (or individual) wants a digest of ideas, not references, and tends to judge a service first as to its reliability. These three functions attach entirely different connotations to the same words for key parameters. They can be linked to the structure of language: operations is the present participle (doing), research concerns the verbal adjective (state of the art), and planning is in the subjunctive mode (could or should). Apparent conflicts may be resolved by dimensional analysis of differences in values perceived are illustrated by case histories, interviews, and questionnaire results.

17. Key Words and Document Analysis. 17a. Descriptors

- Information services
- Purchased services
- Selection process
- User values
- Value priorities
- Value dimensions
- User populations
- Use functions
- Discriminant factors
- Quantifiable
- Qualitative
- Judgmental
- Interaction effects
- Conflicting definitions
- Usage survey
- Information access
- Access tools
- Routine searching
- Information analysis
- Management planning
- Decision analysis

17b. Identifiers/Open-Ended Terms

- Matrix interactions
- Semantic linkages
- Perturbation analysis
- Working bias
- Verbal functions
- Concept analysis

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