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ORGANIZATION AND MANAGEMENT OF R AND D

The Utilization of Information Sources During R & D Proposal Preparation

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ABSTRACT

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Twenty-two proposal competitions for government R & D contract, involving 156 proposal teams, are examined to determine the relative use of three sources of technical information. The extent to which each proposal team relied upon literature search, the use of staff specialists within the lab and the use of outside sources of information is related to the rated technical quality of its proposal, and to other variables characterizing the proposal team and its parent laboratory.

Twenty-two percent of the total time expended by 156 proposal teams was devoted to the seeking and gathering of technical information. Of the three information sources used, only one, laboratory specialists, appears to be at all directly related to the technical quality of the product and this relation is weak and unreliable. Technical quality is inversely related to the extent to which the proposal team relies upon individuals outside of the laboratory as sources of information.

Author

Introduction

Analysis of the effectiveness of the national research and development effort directs attention to the process of information transfer--the generation, storage, summarization, and retrieval of the ideas and data of science and technology. The report of the President's Science Advisory Committee on Science, Government, and Information (1963) stresses the essential point that "the information process is an integral part of research and development. Research and development cannot be envisaged without communication of the results of research and development; moreover, such communication involves in an intimate way all segments of the technical community, not only the documentalists.

"We place special stress upon what seems an obvious point because, in the early days of science, the problem of communication could be managed casually. Each individual scientist could work out his own private communication system, suitable to his own needs, and, since the requirements were relatively small, the whole matter could be treated rather incidentally. But with the growth of science a casual attitude toward communication can lead only to insufficient communication. Scientists individually, technical societies, agencies supporting research and development, will have to recognize that adequate communication no longer comes free. Communication cannot be viewed merely as librarians' work, that is, as not really part of science. An appreciable and increasing fraction of science's resources, including deeply motivated technical men as well as money, will inevitably have to go into handling the information that science creates" (p.14).

The overriding questions of the design and scale of information systems can only be solved, however, with better knowledge of the information needs of the users and an understanding of the role which technical information plays in research and development. A first step in this direction is the measurement of both the relative dependence upon and benefits derived from specific sources of information. Information handling serves two principal functions: (1) management; i.e. direction, coordination, reporting, and control, and (2) technical problem solution. This report is concerned primarily with the second function. Following Menzel (1962) the study considers the use of and interaction among three general sources of technical information.

Previous studies have asked researchers, by interview or questionnaire, what knowledge they needed, what sources they made use of, and what function the information served (Brownson, 1960). These studies have been analyzed and compared in a monograph prepared for the National Science Foundation by the Bureau of Applied Social Research of Columbia University (1960). Other work has dealt with the reading behavior of scientists (Hensley, 1962; Scott, 1962), and the flow and use of information and ideas in university and industrial research (Bureau, 1958; Rubenstein and Avery, 1959; American Psychological Association, 1963). It should be noted that the judgment of the researcher has been the only criterion of the value of the information. In this study, an objective, external evaluation of solutions is related to the information source utilized.

COMPARISON OF INFORMATION SOURCES

Research on research is intrinsically difficult because the outcomes of different projects cannot be directly compared. The opportunity to obtain replication of attempted solutions to the same research problem is rare. Seldom do two or more groups undertake to solve the same problem at the same time (same state of knowledge). This is inevitable because any research study attempts to perform a unique task. If the problem has previously been solved it is, by definition, not a research problem. Yet in order to relate exposure to information channels with performance, an instance must be sought in which the same problem is attempted by two or more research groups.

The present study utilizes a relatively unique situation in which simultaneous parallel research activity exists, that of the government-sponsored R & D proposal competition.

In contracting for research and development, a government agency often solicits proposals from a number of firms having previous experience or interest in the relevant field of endeavor. The technical staff of the agency draws up a work statement describing the mission the system is to perform and setting forth certain criteria to which the design must conform. This work statement is incorporated in a formal Request for Proposal (RFP) which is sent to the chosen firms. A period of 30 days to six weeks is usually allowed for the firms to prepare their responses. A response will generally comprise three sections: technical, management and cost. This study is concerned with the information sources employed during the preparation of the technical portion of the proposal and with the proposal's subsequent evaluation.

METHOD

Data Collection

Twelve contracts[1] were selected from the files of the United States Air Force's Electronic Systems Division. The Air Force Cambridge Research Laboratory was the agency responsible for technical evaluation of the proposals for these contracts. Ten contracts were selected from the files of the National Aeronautics and Space Administration's Marshall Space Flight Center (MSFC); the proposals for these contracts were evaluated by the technical personnel of MSFC. The ten USAF contracts ranged in value from $11,000 to $556,000; the NASA contracts from $30,000 to $169,000. At both centers evaluations are performed by specialists who evaluate technical quality of the proposals separate from and independent of the cost for which each laboratory proposes to perform the job. Contract awards are made by others after considering both technical quality and cost.

Questionnaires were sent to the managers of all 198 proposal teams competing for the contracts to elicit information on the characteristics of their proposal effort. Satisfactory returns were obtained from 156 proposal managers in 112 firms. The number of replies for the individual competitions ranges from four to twelve with a median of seven.

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[1] The twelve contracts include two which were studied and reported in a previous paper (Allen and Marquis, 1963). Interviews were conducted with most of the 21 proposal managers in the preliminary study in order to test and refine the questionnaire.

Data Reduction and Analysis

The questionnaire asks the extent to which the proposal team members utilized each of three sources of information: literature search, specialists within the company (but not assigned to the team), and outside sources (consultants, potential vendors, university professors, etc.). Additional data are gathered on the characteristics of the proposal team, its individual members, and the laboratory (Table 1). For correlations with technical rank, a non-parametric measure, the Kendall tau coefficient (^{t}), (Kendall, 1962), has been chosen since the data on technical evaluations are in rank-order form. This limitation does not hold true for the other variables, and Pearson product moment correlations (^{r}) are computed for their interrelations. For each proposal competition there are 4 correlations with the criterion of technical quality, and 37 intercorrelations among the remaining variables.

In order to aggregate the data from 22 sets of correlations into composite scores for each variable a weighted average correlation is employed (Moroney, 1956). This method weights individual correlations by using the Fisher z transform and a measure of sample size for each correlation (n_i -3, where n_i is the number of observations in each correlation).[2]

In a survey of this sort, there is always the danger that missing data will bias the results. For example, if the 42 proposal managers who failed to return questionnaires were those who had managed very unsuccessful proposals (near the lower extreme technical

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2 For a description of this technique and derivation of a method for testing statistical significance of weighted average correlations, see Allen and Marquis, 1964.

TABLE I

VARIABLES MEASURED IN THE STUDY

Category	Variable Number	Description
	0	Technical quality
Information sources		
	1	Total time spent in consulting with information sources(2+3+4)
	2	Time spent in literature search
	3	Time spent consulting with specialists within the laboratory
	4	Time spent consulting with sources of information outside of the laboratory
Other characteristics of the proposal effort		
	5	Level of effort
	6	Time spent in analytic design
	7	Time spent in breadboarding & other benchwork
Characteristics of the proposal team		
	8	Proposal team size
	9	Level of education and experience of the proposal team
Characteristics of the parent laboratory		
	10	Size of technical staff
	11	Ratio of technical staff to total employment

ranking) the sample and results would be biased toward more successful proposal teams. To test this possibility, the frequency distribution with respect to technical rank, of the completed questionnaires was tested against the frequency distribution of ranks in the total population. A Kolmogorov-Smirnov One Sample Test reveals no significant difference between the two distributions.

RESULTS

Total Time Spent in Consulting with Information Sources

Research and development may be characterized as an iterative problem solving process, with proposal preparation representing, if not the first, then one or several of the early iterations. Each iteration furthermore involves a hierarchical ordering of design decisions. Each decision, in turn, is reached on the basis of some quantity of information describing desired performance and the environmental and technical constraints. This paper concerns itself with the sources of information employed in coming to design decisions during proposal preparation.

The parameter, "total time spent in consulting with information sources", is defined as the summation of the time spent in literature search, and in consulting with technical specialists both within and outside of the company. Twenty-two percent of the total time expended by the 156 proposal teams was devoted to the seeking and gathering of information from these three sources. Total time spent consulting information sources is unrelated to the rated technical quality of the proposal (Table II). This is true even when highly intercorrelated variables such as, the level of effort in preparing the proposal; time spent in analytic design; proposal team size; or ratio of technical staff to total employment are taken into account. It will be seen that this is at least partially a result of relations between technical quality and individual sources of information which oppose and nullify one another.[3] To overcome this deficiency, multiple correlations relating each variable to variables one, two and three ($R_{i.1,2,3}$) are computed and averaged over the 22 proposal competitions. In case of technical rank, such a procedure is not strictly legitimate, and this is the principal reason for resorting to a derived summation variable. In addition, of course, the summation variable provides an indication of direction and allows the computation of partial correlations. For variables other than technical rank, both the multiple correlation coefficient and the correlation coefficients for the summation variable are shown in Table II.

Since the investigator was still interested in gaining at least an estimate of the total impact of the three information sources upon technical quality of the proposal, the invalid assumption that technical ranks form an interval scale was made and multiple correlations performed. Given this assumption, the three information sources are found to account, on the average, for 50% of the variation in technical rank.

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[3] The nullification effect is peculiar to the way in which the variable is defined. Since it is the summation of the values of three other variables, if one of the three variables is directly related to a fourth, and one or both of the remaining two are inversely related to the fourth variable, then the correlation of the summation variable with the fourth vari- will be somewhere between the extremes. In other words, if, for example, $r_{1,4} = 0.50$, $r_{2,4} = -0.50$ and $r_{3,4} = 0$, then $-0.50 < r_{5,4} < 0.50$, where variable five is the summation of variables one, two and three.

TABLE II
USE OF ALL INFORMATION SOURCES

Mean time consulting all information sources:	55 man-hours
Median time consulting all information sources:	25 man-hours
Range:	0-518 man-hours
Number of proposal teams:	156
Number of proposal competitions:	22

Relation of total time spent consulting with information sources (I) to:	Average correlation coefficient (for the summation)	Average multiple correlation co-efficient $R_{I.2,3,4}$
0. Technical quality of the proposal	-0.02	---
5. Level of effort	0.50**	0.79
6. Time spent in analytic design	0.40**	0.83
7. Time spent in breadboarding and other benchwork	0.26*	0.85
8. Proposal team size	0.35*	0.71
9. Average level of education of proposal team ***	-0.07	---
10. Size of technical staff	-0.06	0.73
11. Ratio of technical staff to total employment	-0.36**	
Partial Correlations:		
Technical quality with level of effort constant $(\hat{r}_{I,0.5})$	-0.03	
Technical quality with time in analytic design constant $(\hat{r}_{I,0.6})$	-0.05	
Technical quality with proposal team size constant $(\hat{r}_{I,0.8})$	-0.05	
Technical quality with ratio of technical staff to total employment constant $(\hat{r}_{I,0.11})$	0.05	
Time in analytic design with level of effort constant $(\hat{r}_{I,6.5})$	0.23	
Level of effort with proposal team size constant $(\hat{r}_{I,5.8})$	0.71	
Proposal team size with level of effort constant $(\hat{r}_{I,8.5})$	0.05	

* significant at 0.05 level, ** significant at 0.001 level

Time spent gathering information is strongly related to the time spent in processing it (analytic design), even when level of effort is held constant (Table II). Partial correlations show that the relation between use of information sources and proposal team size is simply a result of the fact that larger proposal teams engage in more total activity and use of information sources increases accordingly. This can be seen quite clearly, since the correlation between use of information sources and proposal team size disappears when controlled for level of effort ($\hat{r}_{1,8.5} = 0.05$), but the converse grows stronger ($\hat{r}_{1,5.8} = 0.71$).

The amount of time spent consulting information sources is inversely related to the ratio of technical to total employment in the lab. This indicates the possibility that laboratories with a higher proportion of technical-professional personnel are able to assign engineers, who are more experienced or more competent in the requisite technical area, and have to rely less upon external sources of technical information. The absence of a correlation in the case of educational level, can be interpreted in this line of thinking to mean simply that this measure is inadequate to identify competence in particular technical areas.

Literature Search

Published literature has traditionally been the vehicle for the com-

*** arrived at by arranging educational attainment levels in the following ordinal scale, and using rank order correlations:

1. Ph.D. engineering or science
2. M.S. engineering or science
3. B.S. engineering or science
4. No college degree, but engineering job classification
5. B.B.A. or B.S. in Business Administration

munication of scientific and technological findings. The proposal writer is in a position where he must be conversant with the state-of-the-art in many areas; he must search out cues from all fields of science and technology. As a result, those engineers who are primarily engaged in new business areas must work continuously to keep abreast of developments.

In asking proposal managers to estimate the number of man-hours spent by their teams in literature search, we find this to be one of the most difficult of our questions to answer. In many cases, the respondent will make an estimate but then note that since this is a continuing activity it is very difficult to accurately apportion it among the various projects and proposal preparations which might be underway.

Nevertheless, for the sample, literature search is the most heavily employed means of seeking information. It represents 52% of the information gathering time and 11% of the total time in proposal preparation. No relation is found in aggregate between literature search time and rated technical quality (Table III). Of the correlations on individual competitions, only two are statistically significant at the 0.05 level. One of these was positive ($t_{2,0}$ = 0.75) and the other negative ($t_{2,0}$ = -0.54). The absence of a relation is not changed by accounting for total time spent in proposal preparation; time spent in consulting with laboratory specialists; or time spent consulting with outside sources of information.

Literature search is not used to the exclusion of either of the other information sources considered. Those teams which rely more heavily

TABLE III
USE OF LITERATURE SEARCH

Mean time in literature search:	28.4 man-hours
Median time in literature search:	15 man-hours
Range:	0-450 man-hours
Number of proposal teams:	156
Number of proposal competitions:	22

Relation of time spent in literature search (2) to:	Average correlation coefficient
0. Technical quality of the proposal	0
3. Time spent consulting with specialists within the laboratory	0.43**
4. Time spent consulting with outside sources	0.39**
5. Level of effort	0.48**
6. Time spent in analytic design	0.18
7. Time spent in breadboarding and other benchwork	0.23*
8. Proposal team size	0.25*
9. Average level of education of the proposal team***	-0.13
10. Size of technical staff	-0.12
11. Ratio of technical staff to total employment	-0.21*
<u>Partial correlations</u>:	
Technical quality (with time spent consulting with laboratory specialists constant) ($\hat{r}_{2,0.2}$)	0.01
Technical quality with time spent consulting with outside sources constant ($\hat{r}_{2,0.3}$)	0.05
Technical quality(with level of effort constant) ($\hat{r}_{2,0.5}$)	0.04
Technical quality with ratio of technical staff to to total employment constant ($\hat{r}_{2,0.11}$)	0.08
Ratio of technical staff to total employment with level of effort constant ($\hat{r}_{2,11.5}$)	-0.13

* significant at 0.05 level
** significant at 0.001 level
*** Rank order correlations. Refer to Table II for the method of ranking

upon the literature use at least one of the other sources to a greater extent as well. The nature of the contract being sought affects the choice between the other two sources. On proposals for contracts in excess of $80,000 (median price), teams rely more on the literature also used laboratory specialists more; on proposals for contracts which were less than $80,000 in value, teams using the literature more consulted outside sources more. This may be attributed to the fact that the larger contracts attract larger laboratories and these have the staff available for technical consultation. Smaller firms seek information through the literature and through other sources outside of the lab.

Larger laboratories and those with a higher ratio of engineers and scientists spend less time with the literature. Presumably these labs are able to form proposal teams with a higher level of education and experience and their members are either able to rely more upon information gained through their education and experience or are more efficient in their use of the literature. A weak inverse relation between literature search time and level of education tends to support this possibility.

Figure I illustrates this situation. Each point in this figure represents the average value across the 22 proposal competitions of the normalized time spent in literature search by proposal teams placing in a given rank. Actual man-hours reported are normalized relative to the mean value for a competition in order to afford comparability among the 22 competitions. It is readily apparent that none of the proposal teams deviated significantly from the mean time (1.0 on the abscissa) for its particular competition.

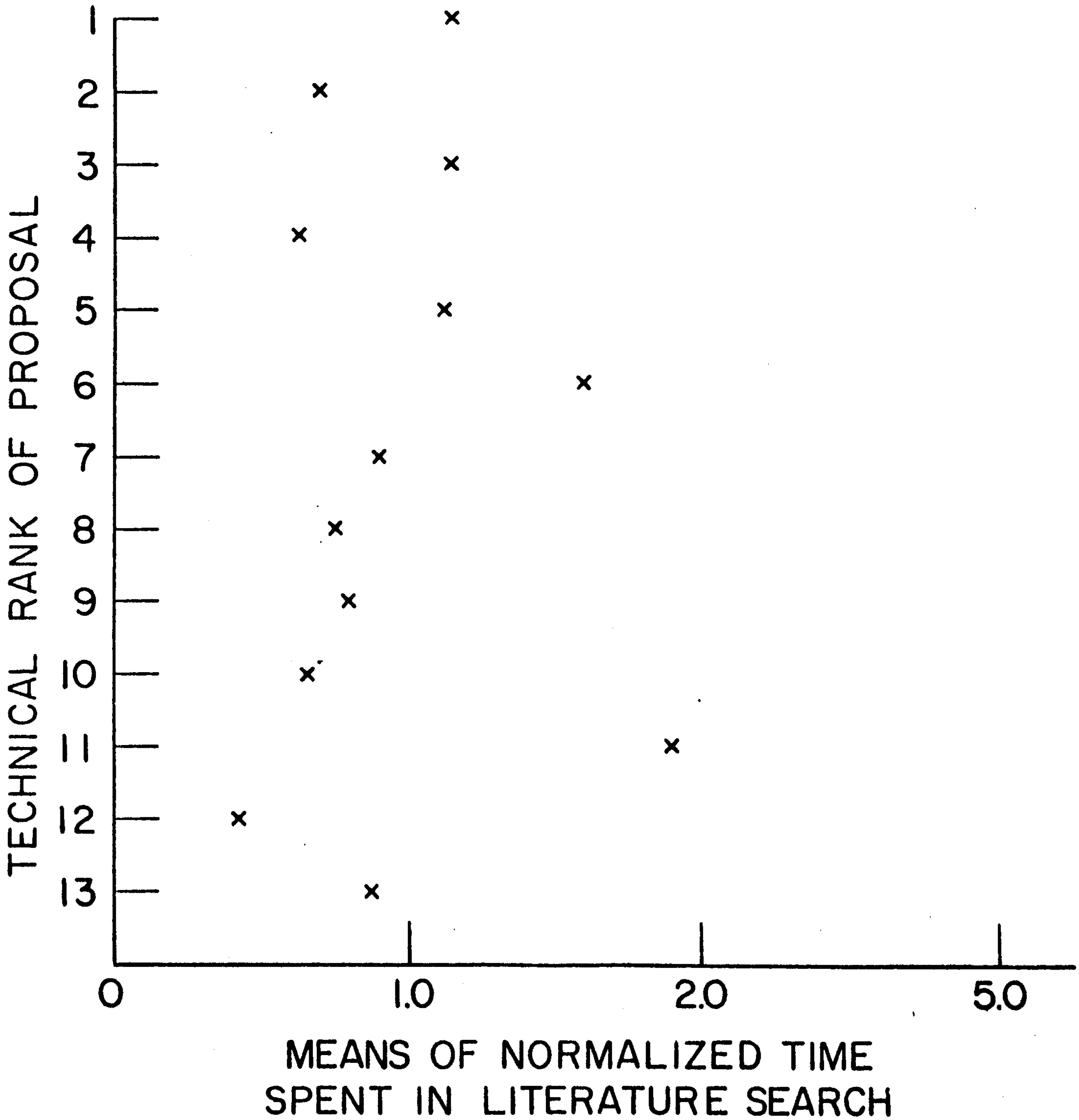

Figure 1. TIME SPENT IN LITERATURE SEARCH VS. TECHNICAL RANK OF PROPOSAL (22 R & D PROPOSAL COMPETITIONS)

Time Spent with Laboratory Specialists

Allen and Marquis (1964) have discussed the economics of the assignment of personnel to the proposal team. They show that very often it is undesirable or impractical to assign the best talent in a laboratory to a proposal team on even a part-time basis. There are many reasons for this. The expected gain from the proposal may not approach the opportunity cost of removing these men from other projects; the portion of the work actually requiring their talent may be quite small; or it may be more desirable to force others to increase their knowledge in a particular area and the writing of a proposal (since it will be evaluated) provides the necessary motivation to accomplish this. At any rate, the best men are often not assigned to the proposal team. They are, however, generally available to the proposal team members for advice and consultation. Such a compromise is compatible with the above objectives and may still be an efficient means of bringing the necessary talent to bear upon the proposal.

To determine the extent to which this practice is followed, the survey asked proposal managers to estimate the number of man-hours which their men spent in consulting with specialists within the laboratory who were not assigned to the proposal team. Use of specialists within the laboratory represents 31% of the information-gathering effort on the part of the proposal teams and 7% of their total effort.

Results of the pilot study of two proposal competitions (Allen and Marquis, 1963) suggested the hypothesis that technical quality is directly related to the extent to which functional specialists within the laboratory are consulted on technical matters. With the additional

TABLE IV
USE OF SPECIALISTS WITHIN THE LABORATORY

Mean time in consulting with laboratory specialists:	17.2 man-hours
Median time in consulting with laboratory specialists:	8 man-hours
Range:	0-200 man-hours
Number of proposal teams:	156
Number of proposal competitions:	22

Relation of time spent consulting with laboratory specialists (3) to:	Average correlation coefficient
0. Technical quality of the proposal	0.12
2. Time spent in literature search	0.43**
4. Time spent consulting with outside sources	0.09
5. Level of effort	0.39**
6. Time spent in analytic design	0.56**
7. Time spent in breadboarding and other benchwork	0.23*
8. Proposal team size	0.44**
9. Average educational level of the proposal team***	-0.12
10. Size of technical staff	0.25*
11. Ratio of technical staff to total employment	-0.30*
Partial correlations:	
Technical quality with level of effort constant ($\hat{t}_{3,0.5}$)	0.14
Technical quality with time spent in literature search constant ($\hat{t}_{3,0.1}$)	0.12
Technical quality with time spent consulting with outside sources constant ($\hat{t}_{3,0.3}$)	0.13
Technical quality with time spent in analytic design constant ($\hat{t}_{3,0.6}$)	0.08
Technical quality with proposal team size constant ($\hat{t}_{3,0.8}$)	0.03
Technical quality with ratio of technical staff to total employment constant ($\hat{t}_{3,0.11}$)	0.14
Level of effort with proposal team size constant ($\hat{r}_{3,5.8}$)	0.36
Proposal team size with level of effort constant ($\hat{r}_{3,8.5}$)	0.25

* significant at 0.05 level, ** significant at 0.001 level, *** Rank order correlations, refer to Table II for the method of ranking.

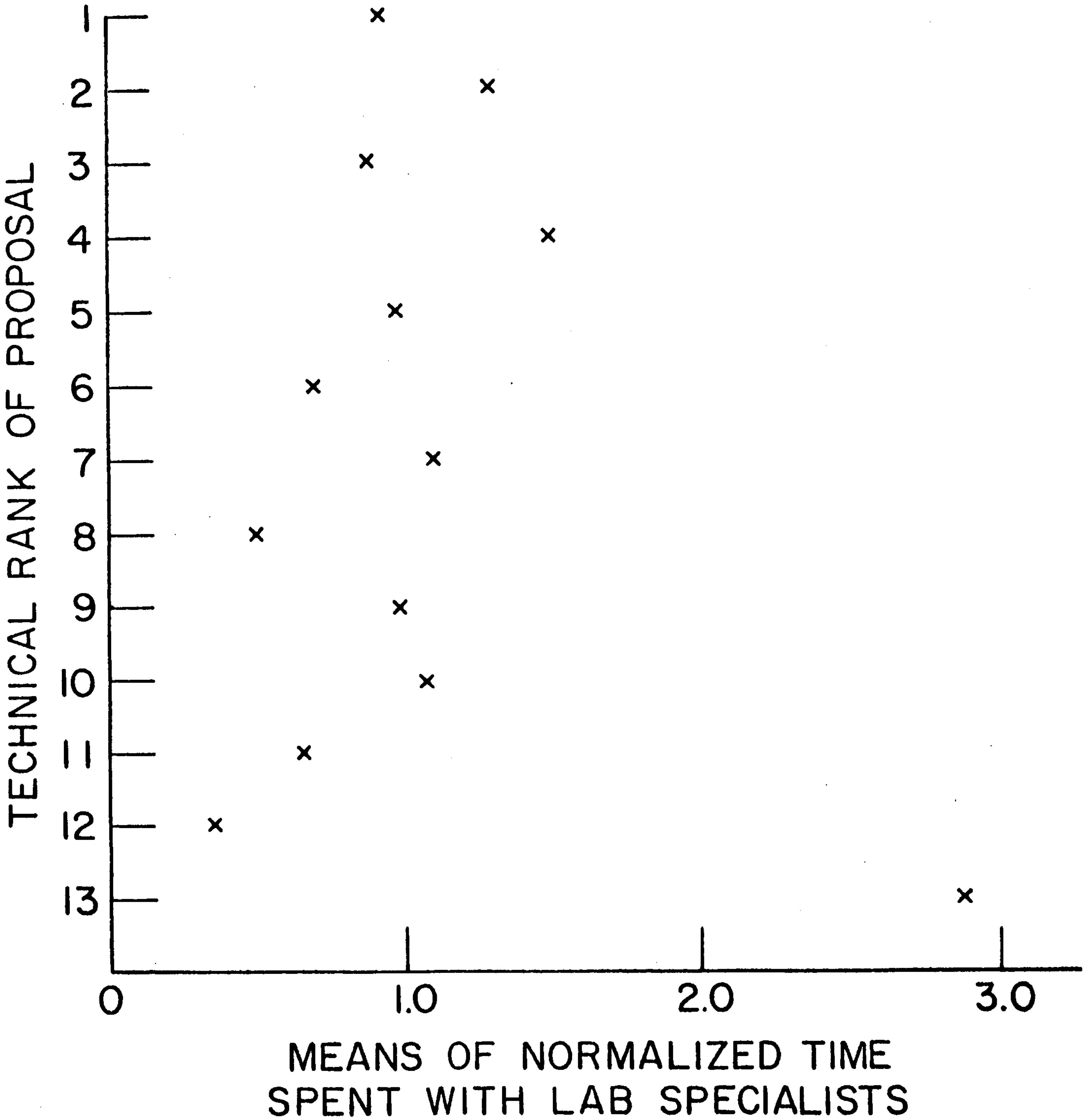

Figure 2. TIME SPENT WITH LABORATORY SPECIALISTS VS. TECHNICAL RANK OF PROPOSAL (22 R & D PROPOSAL COMPETITIONS)

data now available, the relation is in the predicted direction (Table IV) but is weaker than expected, although statistically significant at the 0.05 level (one-tailed). The plot of means of normalized values for each rank in figure 2 illustrates the rather weak relation obtained.

Reliance upon laboratory specialists is strongly related to the size of the proposal team: the larger the team, the greater the contact with specialists who are not on the team. The increased use of laboratory specialists by larger proposal teams can of course be attributed to the fact that larger proposal teams generally spend more time in all activities. The relation, however, remains strong even when controlled for level of effort, indicating that the increased interaction with other members of the organization is a function of the size of the proposal team *per se* as well as being a result of their increased general effort.

Thus we see that increasing the size of the proposal team increases its ability to perform information gathering functions. As new members join the team, they bring with them potential links to distant parts of the organization which may provide information of value to the proposal. Such potential communication links develop as a result of an individual's experience within the organization over a number of years. Increasing the size of a proposal team and bringing in people from diverse parts of the lab may well be an effective way to make more complete use of the broad range of competences available, and to stimulate greater interaction and communication among these organizational parts. Pelz (1956) has shown scientific performance to be related to the frequency of contact with "scientific colleagues who on the average have been employed in scientific settings different from one's own, who stress values different from one's own, and who tend to work in scientific fields different from one's own." This may indicate a way to improve the performance of a research organization by increasing the probability of contact among its researchers who are working in remotely related areas.

The larger laboratories (those having both large technical staffs and a low ratio of technical staff to total employment) are the ones which principally resort to this device. In many cases, these labs use men having less education in their proposal teams, but compensate by increasing the size of the team and thereby its propensity to interact with and gather information from other segments of the organization. This practice not only leaves the technical specialists free to work on other projects without seriously injuring the proposal's quality, but it has such important side benefits as educating the people who are assigned to the team, and maintaining, through exercise, the communication lines among far-flung parts of the organization. Of course, such a practice can be carried too far. If too many proposal team members begin wandering about the organization asking others to do bits and pieces of their work for them, the point can easily be reached where the staff specialists will have little time for their normal assignments. Since the reward structure in R & D labs is normally based on an evaluation of the contributions which a man makes within his own group and disregards any contribution which he might make as a consultant to another group, a practice such as this is bound to arouse resentment on the part of the consultants. This can, of course, be countered by moderation in practice and perhaps by recognizing the value of certain of the specialists as consultants, and modifying the reward structure accordingly.

Time Spent with Outside Sources of Information

Many writers on the subject of proposal preparation recommend the use of outside consultants as a possible substitute for expertise not available within the laboratory (cf. Bjorksten, 1965; Karger and Murdick, 1963). Conversations with both proposal managers and professional consultants reveal this to be a rather popular device for compensating in specific critical areas of technology. In spite of its general acceptance, there is some evidence of dissatisfaction with the system as presently used. Proposal managers often complain that they don't get their money's worth from consultants, or that even informal, unpaid consulting is not worth the time required (opportunity cost); consultants on the other hand reply that they are brought on board too late and then, only when the proposal team has proceeded too far with the remainder of the design in ignorance of the problem area. The data support these complaints to the extent of confirming the existence of some serious difficulty in the relationship between the proposal team and information sources outside of the company.

Outside sources were defined to the respondents in a very broad sense as any individual or group outside of the company who made a technical contribution to the problem. This includes consultation on any basis: paid or unpaid, formal or informal, and would include colleagues in professional societies, potential vendors, or neighbors, as well as professional consultants. Time spent consulting with outside sources represents 15.9% of the total information gathering time and 3.5% of the proposal preparation time. In terms of time expended then it is a relatively minor component of the proposal effort; in terms of providing key problem solutions it can, of course, be critical. Outside sources were employed by more than one laboratory in 15 of the 22 proposal competitions. The correlation analysis which follows is restricted to these 15 competitions.

Teams which rely more heavily upon outside sources produce poorer quality solutions (Table V). Fourteen of the fifteen correlations for individual competitions are negative and range from -0.04 to -0.74. Five of the fourteen individual correlations are statistically significant at the 0.05 level. The single positive correlation ($t_{7,0}$ = 0.42, not significant) involves an experimental investigation of plastic film balloon materials. Figure 3 illustrates the inverse relation by plotting an average of the normalized values for each technical rank across the 15 competitions. While the indications are indeed strong that there is an inverse relation between outside consulting and rated quality, evidence of this sort should not be construed to imply causality. Those teams which rely upon outside help possess other characteristics which more likely are the actual cause of the poor performance. The most plausible of these is simply the lack of the required technical competence within the lab. This is supported by strong inverse relations between the use of outside sources and both the size of the lab's technical staff and its ratio to the lab's total employment. Partialling out these two variables results in a positive correlation between the use of outside sources and technical quality. Laboratories which do not have the necessary technical manpower resources attempt unsuccessfully to substitute through reliance upon outside technical personnel. The failure is probably due to a problem of communication with outsiders. One of the more important components of a technical proposal is the demonstration of an intimate understanding of the problem. Evaluators are not looking for final solutions; what they are looking for is a good first iteration which demonstrates thorough understanding of the nature of the problem being faced and of the customer's requirements. This minimizes the risk of engaging a laboratory that will go off in wrong directions and make grossly inaccurate predictions of the capability or feasibility of approaches. Even when the proposal team members themselves have a thorough understanding of the problem, it can be very difficult and time consuming to raise an outsider to this state of knowledge.

Every R & D laboratory has its own way of attacking problems which members assimilate over time. Some labs are noted for the conservatism of their designs; others are gamblers and are noted for far-out thinking and occasional outstanding breakthroughs. These characteristics as well as certain of the long-run organizational goals become engrained in the members of the organization. This indoctrination and its consequences are described in the following manner by Simon (1957):

> The organization trains and indoctrinates its members. This might be called the internalization of influence because it injects into the very nervous systemsof the organization members the criteria

TABLE V
USE OF OUTSIDE SOURCES OF INFORMATION

Mean time in consulting with outside sources:	11.6 man-hours
Median time in consulting with outside sources:	0
Range:	0-100 man-hours
Number of proposal teams:	116
Number of proposal competitions:	15

Relation of time spent consulting with outside sources (4) to:	Average correlation coefficient
0. Technical quality of proposal	-0.30**
2. Time spent in literature search	0.31**
3. Time spent consulting with specialists within the laboratory	0.15
5. Level of effort	0.16
6. Time spent in analytic design	0.25*
7. Time spent in breadboarding and other benchwork	0.15
8. Proposal team size	0.02
9. Average education level of the proposal team***	-0.02
10. Size of technical staff	-0.20
11. Ratio of technical staff to total employment	-0.24*
Partial correlations:	
Technical quality with level of effort constant ($\hat{t}_{4,0.5}$)	-0.35
Technical quality with time spent in analytic design constant ($\hat{t}_{4,0.6}$)	-0.28
Technical quality with size of technical staff constant ($\hat{t}_{4,0.10}$)	-0.24
Technical quality with ratio of technical staff to total employment constant ($\hat{t}_{4,0.11}$)	-0.22
Technical quality with size of technical staff and ratio of technical staff to total employment constant ($\hat{t}_{4,0.10,11}$)	0.18

* significant at 0.05 level, ** significant at 0.001 level, *** Rank order correlation. Refer to Table II for the method of ranking.
Correlation coefficients in this table are based upon data from the 15 proposal competitions in which two or more laboratories reported the use of outside sources of information. For this reason, they will differ from their counterparts in other tables which are based upon all 22 competitions.

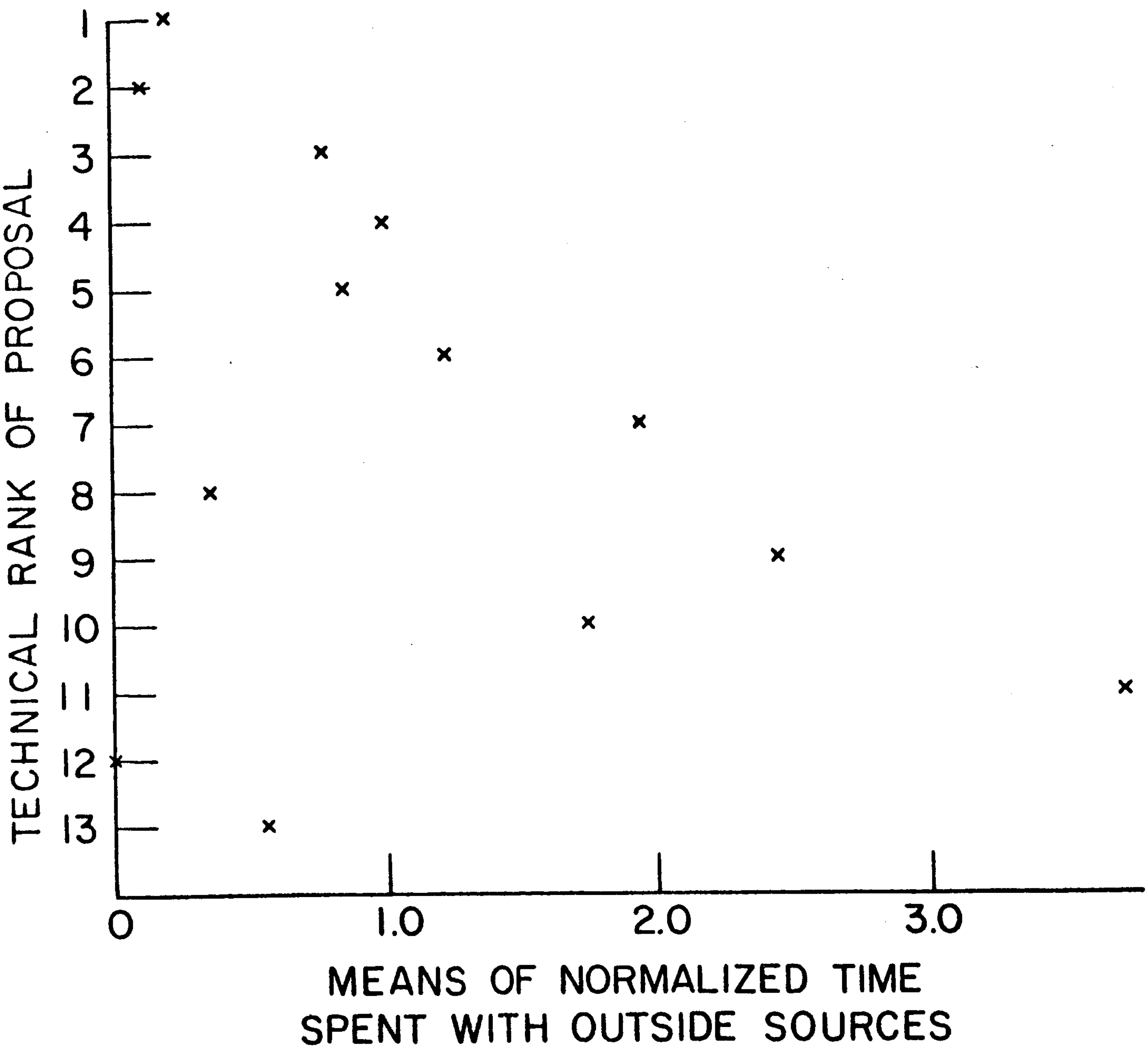

Figure 3. TIME SPENT WITH OUTSIDE INFORMATION SOURCES VS. TECHNICAL RANK OF PROPOSAL (15 R & D PROPOSAL COMPETITIONS)

> of decision that the organization wishes to employ. The organization member acquires knowledge, skill and identifications or loyalties that enable him to make decisions, by himself as the organization would like him to decide.

The preparation of a proposal, which is a document directed toward outsiders and attempting to sell the organization's point of view on a particular matter, will almost certainly be based upon these internalized decision criteria. In order to make use of the contributions of an outsider, such implicit rules must either be conveyed to him or his completed work must be re-interpreted in light of them. What this means is that a greater amount of information must be transferred when communication takes place between the proposal team and consultants who are outside of the company than when communication is with consultants within the company. In the latter case, the decision criteria are stored in what Simon calls the organization's memory and do not have to be made explicit in the communication process.

The severe time constraint under which proposals are written, of course, magnifies the problem. The inadequacy of outside sources may, to a large extent, be a characteristic of the proposal preparation process. The period allowed in the cases studied ranged from 30 days to six weeks. If channels are not set up and outsiders prepared as early as possible (which they complain is often the case) there is simply insufficient time to use them effectively. Because the dysfunctional relation of the use of outside information sources may be a product of the time constraint under which proposals are prepared, the reader should be wary in extrapolating these results to R & D projects of longer duration. Evidence from the data and from interviews with project managers and professional consultants leads to the recommendation to proposal managers that they attempt to predict well in advance the areas in which they will need help on a proposal. The objective is to provide sufficient time to overcome the apparent communication problem, so that they may then derive greater benefit from outside sources of technical information.

Use of outside sources is more strongly related to the amount of time spent in analytic design than to the total number of man-hours spent in preparation of the proposals. Outsiders are utilized in those cases in which a greater amount of analytic work is done during the proposal preparation period. Laboratories which spend less time in analytic work during the proposal preparation period are those which are probably more competent in the required area and may well have performed the necessary analysis prior to the receipt of the RFP (either through pre-proposal research or work of a similar nature on a previous contract) or are simply more efficient. On the other hand, firms spending more time in analysis during the proposal preparation period may be trying to enter a new business area, do not have requisite experience, did less work in the area prior to receipt of the RFP and have to rely, at least temporarily, upon outside competences. The present data are insufficient to test these hypotheses, but it can be seen that outside sources are of little help in improving the technical ranking of the proposal.

The use of outside consulting is related neither to the size of the proposal team nor to its level of education, contrasting with what was found for consulting within the company. The use of outside sources is then not dependent upon having more people available to make the contacts nor does it appear to be used to compensate for lack of education on the part of proposal team members. Outside consulting is unrelated to consulting with staff specialists. So it would appear that the two sources are consulted for different reasons. Staff specialists are probably consulted primarily because they are handy, whereas outside sources are resorted to only when specific problems arise.

DISCUSSION

The failure to find a very strong relationship between use of any of the information sources and rated technical quality of proposals is somewhat surprising. Expectations relative to at least one of the sources are not supported by the evidence. One rather important qualifying question remains unanswered. The study measured expenditure of effort only during the formal proposal preparation period. Work during the pre-proposal period is unknown. We do know from interviews with proposal managers that it is fairly common practice for at least some of the competing labs to gain an early start. The trouble in attempting to measure activity prior to receipt of a request for proposal stems from the difficulty in determining the exact starting point. This is often not clear even in the mind of the proposal manager. Often all of the activity on several earlier projects could justifiably be ascribed to preparation for a given proposal. For these reasons, the survey only attempted to measure activity performed beyond a determinate starting point: the date of receipt of the government's request for proposal. Since labs gaining an early start can reasonably be expected to produce higher quality proposals, the net effect is probably a weakening of the positive correlations with technical quality.

Of the information sources considered, literature search probably suffers most from the inability to measure pre-proposal activity. A forthcoming study of ongoing R & D projects shows that literature, in contrast to the other two sources, is used more heavily during a project's earliest phases. So, if pre-proposal activity could be properly measured, it might be expected that literature search would show some positive correlation with quality. In addition, the correlation between use of staff specialists and quality might be strengthened and the inverse relation between quality and the use of outside sources might even be weakened.

SUMMARY AND CONCLUSIONS

Twenty-two proposal competitions for government R & D contract, involving 156 proposal teams, are examined to determine the relative use of three sources of technical information. The extent to which each proposal team relied upon literature search, the use of staff specialists within the lab and the use of outside sources of information is related to the rated technical quality of its proposal, and to other variables characterizing the proposal team and its parent laboratory.

Twenty-two percent of the total time expended by 156 proposal teams was devoted to the seeking and gathering of technical information. Of the three information sources used, only one, laboratory specialists, appears to be at all directly related to the technical quality of the product and this relation is weak and unreliable. Technical quality is inversely related to the extent to which the proposal team relies upon individuals outside of the laboratory as sources of information. This is partially explained as a result of the lack of in-house talent, with the use of outside sources representing an unsuccessful attempt to substitute for this deficiency.

Among information sources, the use of literature is directly related to both internal and external consulting but there is no relation between the two types of consulting. Most of the proposal teams relied to a considerable extent upon the literature; in addition they consulted with either internal or external sources of expert knowledge or both.

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