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THE PROBLEM OF INTERNAL CONSULTING IN RESEARCH AND DEVELOPMENT ORGANIZATIONS

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ABSTRACT

The results of two distinct research studies which probe the effects of and the deterrants to internal consulting in R&D organizations are presented. The evidence compiled supports the hypothesis that both the extent and diversity of communication by project team members with technical staff are positively related to technical performance. In spite of the benefits to be derived from internal consulting, several psychological costs are identified which deter the engineers from fully utilizing this resource. These psychological costs have their basis both in the individual's perception of the consulting relationship and in the organization's failure to adequately reward this behavior. Specific recommendations are proposed to enhance the utilization of internal consultants through mechanisms designed to reduce these psychological costs.

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Considerable evidence has accumulated in recent years supporting the proposition that research and development laboratories would profit by encouraging more internal consulting. For example, a direct positive relation between technical performance and the extent to which project team members consulted members of their own technical staff was found by Allen (1964; 1966a) in two independent studies. Shilling and Bernard (1964) find that the extent to which informal discussion groups exist correlates positively with eight measures[1] of performance in 64 biological science laboratories.

On the other hand, despite the apparent benefits to be derived from internal consulting, there appears (Allen, 1966a; Gerstberger and Allen, 1968) to be a rather general reluctance on the part of engineers to make complete use of this resource. This aversion to the use of internal consultants is not unique to engineers as is amply demonstrated in Blau's (1963) study of a federal law enforcement agency. However, for reasons that we shall explore, this difficulty is probably more acute among the engineering profession than elsewhere.

The present paper will report data from two independent studies. The first of these explores the nature of the internal consulting process, and relates specific patterns of interaction between technical personnel to the success of the projects on which they are working. The second study focuses on the various deterrents to internal consulting, and explores the reasons underlying engineers' reluctance to consult with colleagues within their own organization.

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[1] Statistically significant ($p < 0.05$) correlations were found with seven of the eight measures.

Four hypotheses are tested:

1. The level of communication (number of times specific communications are reported) between an R&D project member and colleagues within his organization, but not assigned to the project, will be directly related to his performance on the project.
2. The diversity (number of distinct individuals consulted) exhibited by an R&D project member in his communications with colleagues within his organization, but not assigned to the project will be directly related to his performance on the project.
3. When confronted with a need for technical information, an R&D project member will turn to colleagues within his organization as a <u>first source</u> proportionately less frequently than would be expected by chance.
4. Transfer of technical personnel between elements of an organization will be conducive to establishing communication links between those elements of the organization participating in the transfers.

RESEARCH METHODS

The First Study

The first study was performed on three pairs of parallel, or "twin" R&D projects (Allen, 1966a; 1966b). The six projects were each further subdivided into a total of eight subproblems. The use of parallel identical pairs of subproblems controls for variation in the nature of the work being performed (compares the behavior of individuals working on identical problems at the same time) and enables the investigator to obtain relative evaluations of different solutions to the same problems. Relative evaluations

are more easily obtained and are probably more precise and meaningful than absolute evaluations. The evaluations are performed by technical monitors in the government laboratories sponsoring each project.

Data were gathered by means of questionnaires specially designed for each subproblem. The names of each individual's principal colleagues are listed on the left-hand side of the form (Figure 1). A series of numbers is listed next to each name, in part one of the form. Once a week, each respondent is requested to report, by circling the appropriate number, the number of times during that week that he has communicated with each colleague.

If the respondent were merely asked to indicate the aggregate number of interactions, it would be a figure of doubtful validity. Listing each colleague separately increases the accuracy of the measurement. After the first few weeks many individuals kept private records for themselves as interactions occurred. This further decreased any error that might be attributed to memory.

Upon completion of each project, the sets of solutions to parallel subproblems were evaluated by qualified technical monitors in the cognizant government laboratories. Evaluations are obtained at the subproblem, rather than the overall project level, both because such evaluations can be more readily and directly related to individual behavior and because subproblem evaluations are less likely to be contaminated by non-technical performance criteria. The technical monitors determine relative evaluations during a final interview after the teams have presented both written and oral reports of their performance. The ratings were obtained on a nominal scale; the evaluators simply indicated for each pair of solutions to a subproblem which one they believed to be better.

Company XYZ

Name John Doe Date June 13, 1967

Subproblem Alpha

On the above referenced subproblem please indicate by circling the appropriate numbers how frequently in the past week you communicated with each of your colleagues on work-related matters. (Whether by conversation, memos, seminars, etc.)

Name of Colleague	Number of times per week											Other
J. Smith	0	1	2	3	4	5	6	7	8	9	10	____
B. Jones	0	1	2	3	4	5	6	7	8	9	10	____
H. Johnson	0	1	2	3	4	5	6	7	8	9	10	____
S. Green	0	1	2	3	4	5	6	7	8	9	10	____
J. Robinson	0	1	2	3	4	5	6	7	8	9	10	____
____	0	1	2	3	4	5	6	7	8	9	10	____
____	0	1	2	3	4	5	6	7	8	9	10	____

________% of total time was spent on this subproblem, this week.

Figure 1. Form for Gathering Data on Frequency of Communications by R&D Project Members

Four of the six organizations participating in the first study are biological laboratories; the other two are the space sciences laboratories of two large firms. Laboratory A is the microbiology laboratory of the aerospace division of a very large and diversified corporation. Laboratory B is a large biological laboratory. In this instance it is performing under subcontract to a small space research firm. Laboratories A and B, performing parallel projects, are approximately equal in the number of professionals employed.

Laboratory C is located in a unversity medical center and is operating under subcontract to a firm whose principal activity has been aircraft over-

haul, but which has recently begun to expand into space research. D is a large biological laboratory under subcontract to a space research firm. Laboratory E is the space sciences laboratory of a large computer manufacturer. Laboratory F is operated by a large aerospace firm and is comparable in size toE

The work under study may be placed on a continuum midway between basic research and development. The R&D studies are directed and strive toward a result; however, there is no end product and the development is performed at a later stage An example from one of the contracts might best illustrate this point. This study is concerned with man's physiological response to space flight. The task is to develop methodologies for use during flight that will permit analyses to be performed on blood, urine, sweat, saliva, and feces in a zero gravity environment. The physical methods of analysis should lend themselves to use in flight where sample preparation, astronaut training and participation are minimal. The program was intended to establish the feasibility of developing X-ray, electrical and other suitable physical methods for analysis of biological samples under conditions of space flight (weightlessness plus overall volume, weight and power contraints).

The Second Study

The second study was conducted in two divisions of a large aerospace firm. Nineteen[2] engineers submitted weekly forms, for a period of 15 weeks, describing their information search behavior and their progress toward solution

[2] Thirty-three engineers were initially selected. Of these, nineteen remained fully cooperative over the duration of the study and provided complete data sets. A comparison of the 19 cooperating engineers with the 14 non-cooperative ones shows no reason to suspect that they differ in terms of any back ground characteristics, or (from the evidence available) in terms of their information gathering behavior.

of the problems on which they were working. Four of the eight respondents from Division X are associated with a laboratory which is principally involved in systems work. The remaining four are with a components laboratory. The systems and components laboratories of Division X are geographically separated by a distance of about one-half mile. All 11 respondents from Division Y are in the same laboratory, which is located about 18 miles from the two Division X labs. The 19 cooperating engineers range in age from 24 to 43 with a mean of 33 years; six have master of science degrees; the remaining 13 all hold B.S. degrees in engineering. They have been with their present company an average of five and one-half years.

In data gathering, a specially designed questionnaire was employed. This questionnaire supplemented the MIT Solution Development Record (Allen, 1966a; 1966b) with a question about two information searches which the engineer had performed during the previous week (Figure 2). The questionnaire was completed weekly by each engineer. A total of 111 information searches were reported over the course of the study. In addition to the data on specific searches, data on the engineer's problem solving activity and general information gathering behavior were obtained by means of the standard Solution Development Record.

The Solution Development Record is a research tool which provides a record over time of an engineer's progress toward the solution of a technical problem. The engineer is requested to submit a probability estimate, for each alternative approach under consideration, which expresses the likelihood of selecting an approach as the solution to the problem. The set of weekly probability estimates compiled during the duration of the project provides a dynamic record of each individual's problem solving activity.

of the syndrome is still frequently missing. [illegible] of the cases diagnosed from Division X are [illegible] within a [illegible] which is strikingly in- volved in syndrome work. The remaining [illegible] are with a [illegible] background. The systems and components [illegible] of Division X are geographically separated by a distance of [illegible] components from Division X are in the same laboratory, which is located about [illegible] miles from the two Division X [illegible] employees range in age from [illegible] to [illegible] with a mean [illegible] of a large number, the re- maining [illegible] are [illegible] have been with their present company [illegible] of five years or more.

To date [illegible] questionnaire was employed. This questionnaire [illegible] (A) and (B) [illegible] while the rest [illegible] most [illegible] [illegible] [illegible]

[illegible]

Massachusetts Institute of Technology
Solution Development Record

Name Bill Smith   Date July 11, 1967

Problem Beta

alternatives under consideration	estimate of probability that a given alternative will be employed (please circle a probability estimate for each alternative)										
Alternative A	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
Alternative B	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
Alternative C	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
______	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0

(Circled Probabilities Should Add to 1.0)

Please try to recall two instances during the past week when you were actively searching for technical information related to the problem under consideration. For each case please fill in a description of the type of information you sought and indicate the search order of all information channels consulted even though some or possibly all yielded little or no relevant information. (Place a "1" in the space provided in front of the source you consulted first; place a "2" in front of the source you consulted second; and so forth):

(1) Type of information sought: ____________________

____

Search order*: __L__V__C__ES__TS__CR__G__E__D__Other

(please specify): ____________________

(2) Type of information sought: ____________________

____

Search order*: __L__V__C__ES__TS__CR__G__E__D__Other

(please specify): ____________________

Did you obtain the information sought in (1)?: ____ Yes ____ No   in (2)?: ____ Yes ____ No

* Channels are defined as follows:

L = literature: books, professional, technical and trade journals and other publicly accessible written material.

V = vendors: representatives of, or documentation generated by suppliers or potential suppliers of design components.

C = customer: representatives of, or documentation generated by the government agency for which the project is performed.

ES = external sources: sources outside the laboratory or organization which do not fall into any of the above three categories. These include paid and unpaid consultants and representatives of government agencies other than the customer agency.

TS = technical staff: engineers and scientists in the laboratory who are not assigned directly to the project under consideration.

CR = company research: any other project performed previously or simultaneously in the laboratory or organization regardless of its source of funding. This includes any unpublished documentation not publicly available and summarizing past research and development activities.

G = group discussion: ideas which are formulated as the result of discussion among the immediate project group.

E = experimentation: ideas which are the result of test or experiment or mathematical simulation with no immediate input of information from any other source.

D = other division: information obtained from another division of your company.

Figure 2. The Solution Development Record, Modified to Provide Data on the Order of Channel Use in Information Searches.

Figure 2 illustrates the listing of alternative approaches identified from the contract work statement or from the responsible engineer when he is interviewed prior to beginning the task. Blank spaces are always provided so that new approaches may be reported as they arise. If, for example, at some point in the design the respondent were considering two technical approaches, and were completely uncommitted between the two, he would circle 0.5 for each. Eventually as his work progresses, one alternative will attain a 1.0 probability and the others will become zero. Plotting the probabilities over time produces a graphic record of the solution history. A typical plot is shown in Figure 3.

The Solution Development Record, by economizing on the respondent's time, provides an efficient record of a project history. When the project is completed, each respondent is presented with a time-plot of his probability estimates, and is interviewed at some length to determine causes and effects of design changes reflected in this record. The plot thus provides a stimulus to the man's memory and assists the investigator in gathering a detailed record of each project. In this manner quite complete accounts of each engineer's information gathering behavior were obtained over the 15-week period of the study. All interviews were tape recorded and the tapes analyzed for relevant content.

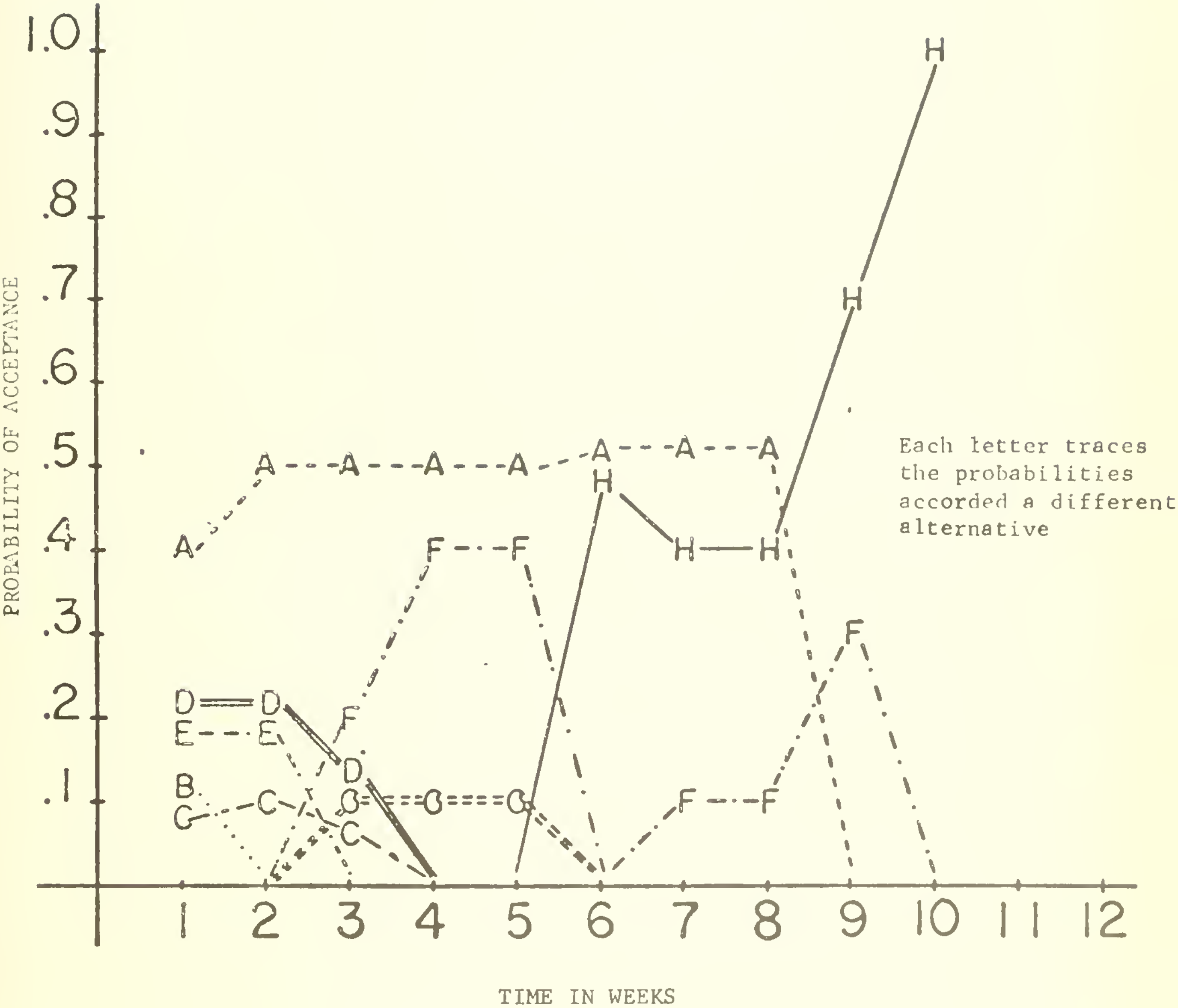

Figure 3. A Typical Time Plot of Solution Development Data.

RESULTS

Data from the first of the two studies are used to test hypotheses one and two. Data from the second study are used to test hypotheses three and four.

In testing hypotheses one and two, the staff of each of the six laboratories will be divided among the following three categories:

1. Engineers and scientists in the laboratory who are assigned directly to the same project as the individual being studied.
2. Engineers and scientists in the laboratory who are <u>not</u> assigned directly to the project being considered but are members of the <u>same</u> functional group as the project member with whom communication is established.
3. Engineers and scientists in the laboratory who are neither assigned directly to the project being considered, nor are members of the same functional group as the individual being studied.

Each of the categories will be considered separately in the analysis.

Level of Communication

Level of communication is measured in terms of the number of times that each project member reports having communicated with a colleague on a work-related matter. These communications could involve one or many colleagues; no consideration is made at this point if the number of people with whom an individual communicates.

Within the Project. In Table I the total number of communications with fellow project members is compared for high and low performing individuals. Although high performers at first appear to communicate more within their project teams, they also on the average spent a greater amount of effort on the project. When this is taken into account, by computing the number of communications per man-hour of effort,[3] the difference between high and low performers disappears. Low performers in fact communicate slightly more frequently for the amount of time they spend, but the difference is not statistically significant.[4]

As a man spends more time working on a project, he naturally communicates more with fellow project members. This increased level of communication is but one of many activities that increase with increased effort. Its contribution if any, to performance cannot be separated from the contribution of these other activities.

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[3]The number of man-hours spent on each subproblem was determined from the respondents' weekly estimate of the percent of time devoted to each subproblem. This information was supplied by the participants on the weekly questionnaire.

[4]When high and low performers are compared on the basis of the amount of time spent in communication within the project team, nearly the same results hold. High performers spend neither a greater amount nor a greater proportion of their time communicating within the project.

TABLE I

Level of Communication Within the Project

Subproblem	Total Number of Communications Reported by:		Communications per Man-Hour Reported by:	
	High Performers	Low Performers	High Performers	Low Performers
a	80	8	0.37	0.36
b	119	45	0.43	0.82
c	238	111	0.61	0.52
d	55	12	0.45	0.18
e	33	7	0.21	0.13
f	66	3	0.20	0.07
g	22	30	0.12	0.55
h	7	20	0.03	1.11
Mean	77.5	29.5	0.30	0.48
	$p = 0.03$ (Mann-Whitney U-Test)		p 0.10 (Mann-Whitney U-Test)	

Within the Laboratory. Considering the extent of communication with organizational colleagues outside of the project, high performers show a far greater reliance upon this source of information (Table II). This difference remains strong even after the data are normalized to account for the greater amount of effort allocated by the high performers.[5]

Colleagues outside of a person's project may be divided on the basis of whether or not they are members of the same functional group (e.g., aerodynamics; structures; electrical power; chemistry; etc.) as the man assigned

[5]When high and low performers are compared on the basis of the amount of time spent in communication with organizational colleagues outside of the project team, nearly the same results hold. High performers spend significantly more and a significantly greater proportion of their total time communicating with colleagues outside of their project team.

TABLE II

Level Of Communication With Technical Staff
Not Assigned to the Project

Subproblem	Total Number of Communications Reported by:		Communications Per Man-Hour Reported by:	
	High Performers	Low Performers	High Performers	Low Performers
a	27	0	0.13	0
b	2[illegible]	0	[illegible]	0
c	169	[illegible]	0.83	[illegible]
d	2[illegible]	[illegible]	0.2[illegible]	[illegible]
e	113	[illegible]	[illegible]	[illegible]
f	[illegible]	[illegible]	[illegible]	0.11
g	36	[illegible]	0.20	0.02
h	[illegible]	0	0.33	0
Mean	6[illegible]	2.[illegible]	0.27	[illegible]
	p = 0.0001 (Mann-Whitney U-Test)		p = 0.002 (Mann-Whitney U-Test)	

to the project. High performers communicate to about the same extent with colleagues both within and outside of their functional group. Furthermore, they communicate with both to a significantly greater extent than do low performers.

High performers communicate with the technical staff of their laboratories to a greater extent on both an absolute basis and proportional to their total effort. The extent to which this information source is used bears a crucial and very powerful relation to project performance.

Diversity in Communication

Given that communication with colleagues outside of an individual's project team is related to technical performance, the relation may still

be dependent upon the number of colleagues with whom an individual communicates. Mere amount of communication, for example, may be unrelated to performance when that communication is directed to a single individual.

Within the Project. Considering the average number of fellow members, with whom an individual reports communicating, no relation is found withperformance (Table III). During the course of their project, both high and low performers consult with an average of two colleagues within the project. Once again,

TABLE III

Diversity of Communication Within the Project

Subproblem	Number of Individuals Communicated With by:	
	High Performers	Low Performers
a	1	1
b	3	3
c	3	5
d	2	2
e	1	1
f	3	2
g	2	1
h	3	1
Mean	2.25	2.0

$p > 0.10$ (Mann-Whitney U-Test)

communication within the project is seen to bear no relation to technical performance. Neither the number of fellow project members with whom an engineer communicates, nor the extent to which he communicates with them has any effect on the quality of the work on his individual subproblem. A possibility remains that more intense communication within the project may

enhance the quality of the overall performance, without contributing to individual subproblem or subsystem performance. This could result from a resolution of subsystem interface problems. Since an exhaustive sampling of subproblems was not attempted on the present projects, and no measure of overall project performance was obtained, the data are insufficient to test this possibility.

Within the Functional Groups. On all subproblems, the higher performers communicated with more colleagues in their own functional groups who were not assigned to the project (Table IV) than did the lower performers. This difference is highly significant statistically.

TABLE IV

Diversity of Communication Outside of the Project
But Within the Functional Group

Subproblem	Number of Individuals Communicated With by:	
	High Performers	Low Performers
a	3	0
b	3	0
c	8	1
d	3	1
e	3	1
f	2	1
g	2	1
h	4	0
Mean	3.5	0.6

$p < 0.001$ (Mann-Whitney U-Test)

Usually the project engineers and scientists are physically located in the same section of the laboratory with other members of their functional

[illegible]

reveal suspected or unexpected requirements. This could result from a resolu-
tion of subsystem interface problems. Time or inadequate coverage of such
problems was not attempted in the present analysis, and no measure of overall
project performance was obtained; the data are insufficient to test this
possibility.

Within the functional groups. In all comparisons, the higher performance was
associated with more [illegible] of their own functional groups [illegible]
assigned to the project [illegible]. This [illegible]
is highly significant [illegible].

TABLE

[illegible]

Subgroups	[illegible]
	[illegible]

specialty. They interact, on the average, to about the same degree with these individuals as with fellow project members. The key difference lies in the fact that high performers make greater use of this resource.

With Other Functional Specialties. Only one of the low performers indicated any contact with a colleague who was neither a project member nor a member of the individual's functional group. Moreover, this one individual reported communicating with only one person (Table V). In contrast to low performers,

TABLE V

Diversity of Communication Beyond Both Project and Functional Group

Subproblem	Number of Individuals Communicated With by: High Performers	Low Performers
a	4	0
b	2	0
c	1	0
d	5	0
e	5	1
f	0	0
g	0	0
h	3	0
Mean	2.50	0.125

$p < 0.01$ (Mann-Whitney U-Test)

high performers report an average of 20 times more contacts with people in this category. Equally important is the observation that so few people in this category are contacted during the course of a project. On the average, over the duration of the six projects, members contacted fewer than two individuals on the laboratory technical staff outside of their project or functional groups.

Intensity vs. Diversity

Since both the level of communication activity and the number of people outside the project with whom an individual communicates, are strongly related to performance, the question remains whether one or the other is the principal contributor. There is, of course, the possibility that both contribute independently.

For this reason Kendall Tau rank order correlations were performed on the data. Three variables were intercorrelated: number of communications with colleagues outside the project; number of colleagues with whom the individual communicates; (outside the project); and performance on the subproblem.[6] The partial correlation between performance and number of communications, holding number of colleagues constant, and the partial correlation between performance and number of colleagues, holding number of communications constant are compared in Table VI. It would appear from this table

TABLE VI

Relation of Two Measures of Communication Outside the Project to Subproblem Performance

	Kendall Tau	Kendall Tau (partialled)	variable partialled out
number of communications with colleagues outside of the project	0.75*	0.31	number of colleagues
number of colleagues communicated with outside of the project	0.75*	0.32	number of communications

*$p < 0.01$

6 Highs were given a rank of one, lows a rank of two on the performance variable.

-42-

Intensity vs. Diversity

Since both the level of consultation activity and the number of [illegible] outside the project with [illegible] interactions, [illegible] strongly [illegible] to performance, the question [illegible] the [illegible] principal contributors. [illegible] the possibility [illegible] exhibit independently

[illegible]

the data. [illegible] with [illegible] the [illegible] [illegible] the [illegible] profile.[9] [illegible] contributions [illegible] [illegible] [illegible] that frequency and diversity of communication are highly correlated, and in fact, they are (Tau = 0.86). Project members then, do not increase the scope or diversity of their communications at the expense of depth or amount of communication with each individual. As a matter of fact, there is some slight indication that the number of communications per person increases somewhat, as the number of people with whom an individual communicates increases. The nine individuals who report communication with one or two persons outside the project report an average of 29.4 communications with each of them. The four individuals who communicated with three or more people outside the project had an average of 64 communications with each of them.

Level of communication increases as the project member's contacts become more diverse, and together they are related to performance on the project. In addition, both appear, independently, to have a somewhat weaker relation to performance. This can be seen in Table VI, where the relations between performance and both level and diversity remain reasonably strong even after partial correlations have been performed.

First Source

Comparing information channels on the basis of the order in which they are contacted by the engineer who has a specific information need, reveals some rather interesting differences. Table VII compares the distributions of first and last choice (channel turned to first or last) in 111 information searches with the distribution of choices that would be expected from observation of the engineer's overall information-search behavior.

If an engineer's probability of selecting particular channels as his first source in an information search were governed by the same factors that frequency and diversity of communication are highly correlated, and in fact, they are (tau = 0.80). Frequent workers then, tend to increase the scope or diversity of their communication [illegible] of topics [illegible] with each individual. As a matter of fact, there is some slight indication that the number of communications per [illegible] increases somewhat as the number of people with [illegible] communication increases. The [illegible] individuals who [illegible] communication [illegible] outside the project [illegible] individuals who [illegible] an average of [illegible]

[illegible]

[illegible]

TABLE VII

Frequency Distributions of Information Channel Use as First and Last Sources

	within the laboratory	outside the laboratory	written channels	experiment	total
expected frequency based on total use	41.8	23.5	24.6	21.1	111
frequency of use as first source	31	17	39	24	111
frequency of use as a last source	41	32	18	20	111

first source: $\chi^2 = 13.42$, $p = 0.003$

last source $\chi^2 = 4.92$, $p = 0.18$

which determine the overall frequency with which he uses those channels, there would be no significant difference in the proportions shown in the first and second rows of Table VII. The fact that the difference is significant indicates that an engineer's selection of a first source is influenced by factors unique to the first choice selection process itself. This proposition is further supported by comparing first and third rows of Table VII. Comparing the frequency with which particular channels appear as the final source in an information search with their expected frequency of use, reveals no significant difference. Final sources are distributed over channels with about the same frequencies that would be expected from observation of overall information use patterns.

Returning to first sources, the technical staff within the laboratory are used far less frequently as a first source than they are used overall. Engineers' reluctance to approach the technical staff of their own organization manifests itself quite strongly when we observe the sources to which they turn first for information. In other words, while other evidence indicates a somewhat general reluctance to use the technical staff as an information channel, Table VII shows this reluctance to be magnified in the case of the first case of the first source approached. It should be noted that the category "oral sources within the laboratory" includes anyone outside of the project team. Had it not included members of the searching engineer's own functional group, indications are that the numbers in both the expected and observed cells of the first column would have been even smaller.

A second interesting point manifested in Table VII is the tendency to use the literature more frequently as a first source than would be expected. One might expect that engineers would contact oral sources first in order to locate what they needed in the literature, and use the literature at later points in the search process. In fact, it appears that they first consult the literature, and only later do they utilize oral sources.

Inter-Divisional Communication

Up to this point, the analysis has focused upon communications within a single division of a laboratory. Since the second study considered three laboratories in two separate divisions of a company, it provided an opportunity to examine the extent of communication between divisions.

It is quite easy to summarize the results by saying that inter-divisional communication was virtually non-existent. Of the 280 instances in which an

engineer reported receiving information, in only five cases (1.8 percent) did that information come from another division of the company. During the course of 111 information searches, engineers sought information from another division of the company only seven times, and they were successful in only three of these.

As a result of this evidence, it was decided to explore the topic of inter-divisional communication during post-project interviews. Each of the participants was asked if he had occasion to contact engineers in other divisions on past or current projects. They were also requested to indicate whether they had ever worked in another division for any period of time and if contact had been established in the past. This could create circumstances leading to the establishment of the communication link.

Responses to the questions fell into the following three categories:

(1) the engineer had never worked in another division of the company and never has had occasion to establish communication with individuals or project groups in other divisions;

(2) the engineer had worked in another division and now used the contacts he had made while an employee of that division or while he was "on loan" to that division;

(3) the engineer had never worked in another division; however, contact had been established through either a member of his immediate project group who had worked at another division or the engineer knew someone in another division who had previously been a part of his own project group and then transferred.

Respondents were split on the basis of whether or not physical transfer of people between divisions had occurred. A contingency table summarizing the relationships between transfer of engineers and the existence of communication links between divisions is provided in Table VIII.

TABLE III

Inter-divisional Personnel Transfer and Communication Links

	contact used	contact not used	totals
transfer of personnel between divisions occurred	13*	0	13
transfer of personnel between divisions did not occur	2	4	6
totals	15	4	19

* on the current project, only two of these people actually used divisional information in the problem solving endeavors that they were reporting on the weekly questionnaires.

A Fisher exact probability test performed on the above data rejects the null hypothesis of no difference ($p < 0.005$). In the two instances where divisional contact was established and no physical transfer of the personnel involved had occurred, the following observations were made. In one case, a vendor served as a link between two engineers in different divisions. He was supplying both with similar components, and he recommended that they contact each other and discuss their current design efforts. In the second case, an engineer used another division's sales organization as a point of entry for technical information. This would most likely be the method employed by someone outside the organization if technical information were desired from that division.

A study by Kanno (1968) of a Japanese chemical firm provides strong support for the transfer of personnel hypothesis. In this particular firm,

inter-divisional transfers were quite frequent as a matter of corporate policy. Kanno measured the frequency of inter-divisional communication by asking engineers for estimates of the number of people contacted during the preceding month in other divisions of the company. He then related these responses to the length of time which had elapsed since each respondent's most recent inter-divisional transfer (Table IX).

TABLE IX

Inter-divisional Communication Frequency and Length of Service Since Last Inter-divisional Transfer

	Number of engineers reporting for whom the time since last inter-divisional transfer is:		
	less than one year	more than one year	never transferred
once every 2 or 3 months	2	16	11
once a month	3	5	7
once every 2 weeks	1	6	3
once a week	2	5	1
once every 2 or 3 days	1	7	2
total number of engineers	12	[illegible]	2[illegible]
mean period between inter-divisional communications (days)	26.1	[illegible]	[illegible]

N = 139, p < 0.001 (Kruskal-Wallis One-Way Analysis of Variance)

Data from Kanno, [illegible]

Engineers who had been transferred less than one year prior to Kanno's study were found to communicate significantly more frequently with other divisions than their colleagues who have been with their present division longer, or who have never been transferred. Surprisingly, those who have never been transferred report slightly more frequent inter-divisional contacts than do those whose last transfer occurred more than one year preceding the survey. The difference, however, is not statistically significant.

The data, Tables VIII and IX, offer substantial evidence that inter-divisional contact can be developed through a physical transfer of personnel. It would appear that a prerequisite for oral technical communication is the development of social relationships between individuals in the laboratory. Qualitative data compiled from the informal post-project interviews further substantiate this conclusion.

DISCUSSION

The present data lend overwhelming support to the contention that improved communications among groups within the laboratory will increase R&D effectiveness. Increased communication between R&D projects and other elements of the laboratory organization were in every case strongly related to project performance. Moreover, it is the import of information into the project from outside that is of real importance to effectiveness. Despite the claims of brainstorming enthusiasts and other proponents of group approaches to problem solving, the level of interaction within the project group shows no relation to problem solving performance. Interaction with colleagues outside of the immediate project group is the factor that leads to a payoff. On complex projects, such as these, the inner team cannot

sustain itself properly without constantly ingesting new information from the external worlds.

Allen (1966a) shows that this information is best obtained from colleagues within the organization. In the present study, high performers consulted with anywhere from two to nine organizational colleagues, whereas low performers contacted, at most, one or two colleagues. This suggests that increasing the number of colleagues with whom an engineer consults, contributes independently to performance. In the present situation, the number of colleagues contacted correlates so strongly with the number of contacts that it is extremely difficult to separate the two for analysis. Given this limitation, the following diagram (Figure 4) best summarizes the inferences which can be drawn from the data.

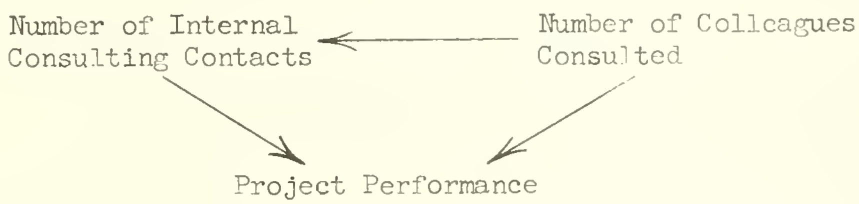

Figure 4 . Contributions to Performance of Breadth and Intensity of Internal Consulting

As the number of consultants increases, so too does the number of consultations, and the two operate in series to produce higher project performance. Concurrently increasing the number of consultants contributes to performance somewhat independently of the number of consultations. This is generally in accord with the findings of Pelz and Andrews (1966) who conclude:

sustain itself [illegible] technology [illegible] information from the external worlds.

Allen (1966a) shows that this information is best obtained from colleagues within the organization. In the present study, the performers consulted with experts from two to nine organizations; the [illegible], whereas the poorer performers contacted, at most, one or two colleagues. This suggests that increasing the number of colleagues with whom an engineer consults, contributes significantly to performance. In the present situation, the number of colleagues contacted correlates so strongly with the number of contacts that it is extremely difficult to separate the two in this data. Given this limitation, the following diagram (Figure 8) best represents the [illegible] which can be drawn from the data.

> "Frequent contacts with many colleagues seemed more beneficial than frequent contact with just a few colleagues. Similarly, having many colleagues both inside and outside of one's own group seemed better than having many colleagues in one place and just a few in the other. So anything you can do to promote these forms of contact should be in the right direction." (p. 53)

Further support for the Pelz and Andrews' diversity hypothesis can be found in the present case. All of the eight high performers reported consulting both with members of their functional group and with colleagues from other functional specialties. The remaining two restricted their consultation within the functional group. Of the eight low performers, only one reported consultation both within and outside of his functional group. None of the remaining seven consulted with individuals whose functional specialty differed from their own.

The Costs of Internal Consulting

Given the obvious benefits resulting from internal consulting, it is interesting that its practice is so infrequent. The project members shown an average of about 10 or 11 contacts with each of three colleagues not assigned to their project. Furthermore, the vast majority of these contacts are within the man's own functional group. Looking beyond the functional group, the average man had but one contact with a single colleagues. This is over a period of three months.

There is either less of a perceived need for communication beyond one's functional group, or else there is a higher cost associated with this behavior. Since the data indicate unequivocally the benefits to be derived, there must be some inhibiting force mitigating against greater use of this information source.

> "Frequent contacts with many delinquents [illegible] the [illegible] than frequent contact with just a few [illegible]. Similarly, having many acquaintances both inside and outside of one's own group [illegible] having many [illegible] in one group and just a few in the other. [illegible] can do to promote [illegible] should be in the right direction." (p. [illegible])

Further support for the [illegible] hypothesis can be found in the present case. All of the [illegible] existing behavior [illegible] group [illegible] other functions [illegible] sion within the functional group [illegible] ported constructive [illegible] within [illegible] of the [illegible] different from [illegible]

The Role of [illegible]

[illegible]

There are always costs as well as benefits associated with the use of any information source. Such costs are not necessarily economic and may involve simply the expenditure of more effort to reach a source or the loss of some self-esteem when admitting to a consultant that you require his assistance. Blau (1963) describes the latter cost in the following manner:

> "A consultation can be considered an exchange of values; both participants gain something, and both have to pay a price. The questioning agent is enabled to perform better than he could otherwise have done without exposing his difficulties to the supervisor. By asking for advice, he implicitly pays his respect to the superior proficiency of his colleague. This acknowledgment of inferiority is the cost of receiving assistance." (p. 130)

In describing the extreme case in which a man comes to rely heavily upon intra-organizational consulting as a source of information, Blau continues:

> "Asking a colleague for guidance was less threatening than asking the supervisor, but the repeated admission by an agent of his inability to solve his own problems also undermined his self-confidence and his standing in the group. The cost of advice became prohibitive if the consultant, after the questioner had subordinated himself by asking for help, was in the least discouraging -- by postponing a discussion or by revealing his impatience during one." (p. 131)

To an engineer, this cost is at least equal to, and perhaps many times greater than, that for Blau's agents[7] (Cf., Shepard, 1954). An engineer's prestige among his colleagues is founded to a great degree upon an almost mystical characteristic called "technical competence." To admit a lack of technical competence, especially in an area central to the engineer's technological specialty, is to pay a terrible price in terms of lost prestige. Furthermore, the problem is exacerbated when the consultant resides in the same organization as the individual who is seeking help. The individual must not only admit that he needs assistance in an area in which he is supposed to be

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[7]Employees of a government regulatory agency.

technically competent, but he must live with the consultant afterward. He may actually damage his reputation in the organization, or at least be inclined to fear the possibility. This possibility and the resulting inhibitions do not exist for the external consultant. The cost of external consulting to the individual is thus often less than the cost associated with using internal consultants. The prestige loss cannot be nearly as great when the relationship is brief and the chance that any detailed knowledge of the transaction will ever reach one's organizational colleagues is slight. As a matter of fact, the engineer need not even pay this price to the consultant. Since the outsider has no knowledge of the man's organizational reputation, nor of the specific technical content of his responsibilities, the engineer can easily excuse his lack of knowledge by pretending to be an "expert in something else" who needs some help in "broadening into this new area." By such a strategem, the engineer can disguise his lack of competence in an area in which he is supposed to be knowledgeable, and run little risk that anyone in his parent organization will ever learn of his game. The ruse would, of course, not work as well when consulting with someone within the lab since the risk of being exposed is far too great.

Considering the other end of the transaction, Blau continues:

> "The consultant gains prestige, in return for which he is willing to devote some time to the consultation and permit it to disrupt his own work. The following remark of an agent illustrates this: I like giving advice. It's flattering, I suppose, if you feel that the others come to you for advice." (p. 130)

This situation will differ, however, depending on which side of the organizational boundary the consultant is located. For the outsider, it is indeed flattering and it probably enhances his prestige to have it known that people

from other organizations come to him for technical advice. However, for the insider this fact is usually not evident. Someone approaching from within the organization is not as visible as a visitor entering from without, and no one is aware of why the insider is talking to the consultant. For all his supervisor knows, they may be fishing companions talking over last week's (or next week's) catch. The reward is less and the cost greater. The man who consults with outsiders has an organizational blessing on his activity; if this were not the case, the organization would probably have discouraged the visitor in the first place. The internal consultant, on the other hand, pays the full price of spending time at the expense of his organizationally assigned responsibilities. Blau again:

> "All agents like being consulted, but the value of any one of very many consultations became deflated for experts and the price they paid in frequent interruptions became inflated. One of them referred to the numerous requests for his advice by saying, 'I never object, although sometimes it's annoying.' Being approached for help was too valuable an experience to be refused, but popular consultants were not inclined to encourage further questions." (p. 130)

Homans (1961) states the above principle in more precise terms as one of his propositions of human exchange:

> "The more often a man has in the recent past received a rewarding activity from another, the less valuable any further unit of that activity becomes to him." (p. 55)

In more homely terms, an engineer who very frequently seeks consultation will soon wear out his welcome.

During the post-project interviews with the 19 engineers of the second study, the arguments of Blau and Homans found considerable support. In the words of one of the engineers interviewed:

from other organizations come to him for services, advice. However, the com- peting [illegible] that is [illegible] is not [illegible]. Because [illegible] from whence the organization is not as visible as a visitor's coming from without, and we are so aware of why the insider is related to the organization. The [illegible] who [illegible] which knows, they may be finding [illegible] getting that [illegible] work's) catch. The reward is less and the cost greater. "To [illegible] with outsiders has an [illegible] on his activity, it [illegible] out the same, the organization could [illegible] were discouraged [illegible] in the first place. The [illegible] the [illegible] price of [illegible] the expense of his [illegible] abilities. Blau adds:

> "Colleagues [illegible] being [illegible] of very busy [illegible] the price they paid [illegible]. One of them [illegible] This [illegible] [illegible] 's thoughts [illegible] an expert [illegible] [illegible]

"I think people, being human, are somewhat reluctant to go to a person that they don't know. Either you are afraid you are going to look like a schnook when it's all over or you are afraid that this guy may not have enough time. I think everybody goes through this ever since they were kids."

The reluctance to communicate openly is observed not only among newer employees but also among those who have been with the organization for several years. Their perception of the problem is somewhat different from that described by their younger colleagues. An engineer, who had been with the organization for several years, described the situation as follows:

"When you come into a place as a junior engineer, you ask anybody anything and they accept the fact that you are real dumb. After you have stayed awhile, you ask fewer people fewer things. There are certain things that are expected of you and you are a little bit querulous (sic) about displaying ignorance. I think this is a very human reaction. You use some discretion in digging out information."

Strategies for Reducing Cost

Three strategies are used by engineers to cope with these deterrents to open communication. Each of these will be described in some detail with illustrative quotations.

Literary Preparation. The data of Table VIII indicate that literature is sometimes employed to obtain background for oral communication, or to avoid oral communication completely in certain situations. In the words of two of the engineers:

"Literature is frequently used to keep other people from knowing how little you know."

"If I were in a situation where I didn't know anyone, I would most likely ask fewer questions and would try to find out the answer on my own. This would be a case where literature would be most frequently used. I would like to know a little more before I asked a question."

"I think [illegible], using knives, are somewhat [illegible] to a person that they don't know. Either you are afraid you are going to look like a [illegible] or you are afraid that [illegible] you may [illegible] have [illegible] time. I think everybody goes through this [illegible] where [illegible] kids."

The reluctance to discriminate [illegible] not only among the players but also among those who have been with the organization for several years. Their perception of the [illegible] differs from that displayed by their [illegible], and [illegible] with the [illegible] for everyone [illegible] as [illegible]

"When you come [illegible] anybody and [illegible] I know. After [illegible] found [illegible] if you [illegible] play [illegible] I [illegible]

[illegible]

Oil on Troubled Waters. This second strategem was referred to by one engineer as "putting oil on troubled waters." When he requires technical information, he pursues the following course:

> "You have to start some place so I feel it's better to start off by asking stupid questions so you can build up to the intelligent ones, and when I feel it's a stupid question, I'll just simply say that. I don't know any better so I'm going to ask a question and when I get to the obvious, tell me so. If I thought I knew the answer, I wouldn't ask the question. And this perhaps is a way of putting oil on troubled waters. It tends to make the person to whom the question is addressed a little more receptive to the question. You don't want to use this approach too often; pretty soon people will tell you 'Smarten-up, Charlie.'"

The engineer, by employing this approach, anticipates any potentially derogatory reaction by the individual to whom the question is addressed. By denigrating himself, the inquirer deprives his colleague of an opportunity to make a derogatory comment and simultaneously evokes empathy from the engineer being questioned.

Neutral Social Interaction. The third and most commonly cited technique for reducing potential threats to an engineer's ego in interpersonal communication is to restrict communication to those engineers who are also known socially. The term "socially" as used in the present context refers to several types of interaction observed in the laboratory. These may be recreational, such as playing bridge during lunch, or discussing a week-end fishing trip, or they may be an outgrowth of work activity, such as borrowing tools or test equipment. In those interactions evolving from work situations the topics discussed are neutral, that is they do not involve the exposition of technical knowledge, or lack of it.

These neutral social interactions, as well as recreational activities such as bridge, serve the important function of developing interpersonal ill-prepared helper. [illegible]

in "putting off an [illegible] teacher." [illegible]

pronounce the following [illegible]

"You have to [illegible]
off by making, [illegible]
telligent ones, and when [illegible]
Just simply say that [illegible]
to ask a question and when I [illegible]
If I thought I knew the answer, [illegible]
And this perhaps [illegible]
It seems to make the [illegible]
a little more [illegible]
was this [illegible]
'Don't [illegible]'"

The [illegible]

perception [illegible]

[illegible]

[illegible]

being [illegible]

understanding. The engineers indicated that understanding between colleagues is a prerequisite for effective communication on technical matters. Several comments pertaining to this subject were extracted from the post-project interviews. For example:

> "I would say that establishing an initial understanding is the biggest block to communication. For instance, I am thinking of a fellow over at ZZZ Division I got to know pretty well. He was a circuit designer. I'm in microwave. There is quite a gap between the two. He was a very good circuit designer and I get into these circuit problems every once in a while and someplace along the line I got to asking him questions, some of them were very stupid questions. He would answer these, spending a good deal of time and effort, so after I got confidence in talking to him that he would be sympathetic and answer as fully as he could, then I would go ask him anything..."
>
> and
>
> "I think this understanding has to come through personal contact, whether it's through bridge games during lunch hour or contact in the laboratory such as borrowing a person's equipment and returning it, or perhaps having something in common with the person like enjoying skiing or going to town meetings together or something like this."
>
> "Sometimes you will ask someone a question and they will just beat around the bush. They don't know the answer either but they don't want to admit it because they are supposed to have a higher rating than you. If you know the person well enough, then you can joke about the whole thing. By well enough, I don't necessarily know them socially where you go out on the town together every weekend, I mean just perhaps socially like play cards during the lunch hour. Bridge is a big out; it is a big social function as far as I can see."[8]

In a potentially tense situation when either a stupid question is asked or the individual to whom the question is addressed does not know the answer,

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8 It was interesting to note the development of certain social norms around the bridge games in this organization. In addition to being punctual and not keeping the players waiting, there is, for example a taboo against technical discussions during the game. Such discussions are however permitted during coffee breaks.

[illegible]. The [illegible] [illegible] [illegible] [illegible]

are prerequisite for [illegible] [illegible] technical [illegible] [illegible]

comments pertaining to [illegible] [illegible] the post-project [illegible]

tension. For example:

> I would say that [illegible] [illegible] [illegible] as the
> History. [illegible] [illegible] [illegible] [illegible]
> of [illegible] [illegible] [illegible] pretty well.
> He was a circuit designer [illegible] There is quite
> a gap between the [illegible] [illegible] [illegible]
> and I got into these [illegible] [illegible] [illegible]
> and sometimes [illegible] [illegible] [illegible] questions.
> Some of them were [illegible] [illegible] I answer
> these, requiring a good [illegible] [illegible]
> not sufficient [illegible] [illegible]
> and someone [illegible] [illegible]
> thing.

and

> "I [illegible]

a loss of face is averted by joking about the problem. In this manner both individuals are able to continue interacting in an otherwise potentially awkward interpersonal situation; on the other hand, when understanding is absent between the parties involved, blocks to future communication will most likely develop.

The understanding that develops between engineers through their social and work contacts is important not only in encouraging communication but also in increasing its effectiveness. If an individual is familiar with another's background, he appears to be better able to tailor his responses to the man's abilities. In reference to this, one engineer said:

> "Well, I think that in talking to somebody you know, you're familiar with what the person has done before and he probably can speak the language that you understand; whereas, if you talk to somebody whom you don't know, he might not explain it in a language you are used to hearing. Somebody you know understands what your background is and you understand what his is and you usually can get together easier."

The relation between informal social relations and communication network structure has been demonstrated to be a general characteristic of R&D laboratories (Allen and Cohen, 1968; Allen 1967). The informal social structure of the laboratory occupies a very important position in the transfer of information.

Considering the three general strategies to overcome interpersonal barriers to open communication, it would seem that the third approach, that of developing greater understanding through increased social contact, will in the long term be the most effective.

Inter-Divisional Communication

The relatively few technical communication links that existed between the divisions of the organization in the second study all revolved around

interpersonal associations between individual engineers. The operating mechanics through which this occurs are illustrated by an engineer's comments concerning communications among sections within a division:

> "Really the people that I know in other sections worked in my old section originally and transferred out. They become your focal point in the other group. You can go to them and say, 'Jerry, anybody up here working on such and such,' and he'll say, 'I'm not, but Joe is.' Well then I'll go talk to Joe. Jerry will take me over and say, 'Joe this is Harry. He needs some information.' But if I don't know anyone in the group in the laboratory, it's almost as bad as trying to go to another division. Where do you start? There is really no simple way of finding out what is going on elsewhere in the building."

> "I have approached people that I haven't met before but usually through an intermediary. I usually have to go to a contact to find out who their expert is and then <u>we'll</u> go see him."[9]

Another engineer describing the communications problem between divisions amplifies the same point:

> "Whether or not the (Divisions) have the ability isn't the question involved, it's more one of personal acquaintance. While we view the company as a very large organization, it's made up of individuals and individuals would prefer to talk to others that they know personally. Since I know no one on a personal basis from another division, I have no contact with them."

Inter-divisional communication generally involves the following three steps:

(1) <u>Identification</u> - find out who is doing relevant work in the other laboratory.

(2) <u>Establishing Contact</u> - once an individual has been identified as a potential source of technical information, finding an intermediary to perform the introductions.

(3) <u>Information Extraction</u> - obtaining the desired information once contact has been established.

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[9] Emphasis added.

[illegible] associations [illegible] individual engineers. The operation code

users through which this [illegible] are [illegible] by an engineer's [illegible] the

carrying communications among [illegible] within a [illegible].

"Usually the people that I see in other sections started at the old section originally and [illegible]. They [illegible] focal point in the older group. I'll go up to them and say, 'Jerry, anybody in here working on [illegible] work,' and he'll say, 'I'm not, I'll [illegible]. Well then I'll go talk to [illegible] will take me over this way.' [illegible]. We [illegible] some information [illegible] if I don't know anybody in the group [illegible] the laboratory, it's a mess to be [illegible] trying to get to another division. There is [illegible]. There is really no simple way of finding out what is going on somewhere in the facility."

"I have [illegible] time I [illegible] naturally [illegible] a [illegible] go [illegible]."

Another engineer described [illegible] between different

supplying the [illegible]

In many cases the first or second step is omitted or combined into a single operation. In other words, very often the person who identifies a potential source of information also performs the function of an intermediary. Whether or not an intermediary is used appears to be a function of the person to be contacted. It would seem that the higher the person is in the organizational hierarchy, the greater the probability of using an intermediary when contacting him.

The communication between divisions appears to follow this process. Tables VIII and IX offer very strong evidence that the inter-divisional transfer of technical information by engineers depends almost entirely on the establishment of personal contacts. One very powerful mechanism for establishing the necessary social bonds is the inter-divisional transfer of personnel. Several of the interviews clearly demonstrate this point. For example:

> "One of the fellows went to ZZZ Division. Again I knew him real well and if I have a question, I call him right off. Even if he doesn't know the answer, he can say, 'Well somebody over here does,' and when he goes to this person and says, 'Here is somebody I used to work with' you have a link and you get better results that way."

The most disturbing element in all of this is the disinclination of most firms to allow inter-divisional transfer even among their professional personnel. Not only do they fail to encourage transfers but many actively discourage them. One of the engineers in the study, who had been transferred describes the way in which he mediates contacts between divisions and the manner in which his transfer took place:

> "It happens quite often that people (in this division) know that I worked on travelling wave tubes for a long time so they come up with questions. If I can't answer them, I can name the person whom they can contact at ZZZ Division who can answer it for them. The funny thing about this is that this type of inter-divisional transfer is discouraged in general and XXX Company has a policy, an anti-pirating policy, that states that a division cannot hire an engineer

> from another division unless he goes to his own boss and requests permission for what they call a "hunting license" to go looking for a job at another division. In my case, I was loaned to this division and convinced them that I wanted to stay."

It is impossible to determine the proportion of transfers that come about as the result of inter-divisional loans, but it is quite probable that the majority begin in this way. Transfers are virtually never accomplished as the result of an individual's own initiative to effect a transfer. In one extreme case, an engineer reported that he successfully transferred only by terminating, working six months for another company, and then allowing himself to be hired by the division to which he wanted to transfer. We need hardly point out that this is a rather expensive method of effecting transfers.

One more point should be made concerning the transfer of engineers between divisions. Once transferred, an engineer can hardly be expected to mediate effectively between divisions for the remainder of his time with the company. His effectiveness in this role will certainly diminish with time. This is amply illustrated in Table IX. So the company that hopes to promote inter-divisional transfer of technology by transferring people will have to develop a reasonably systematic program of rotation, that will insure the presence of fairly recent transfers in all divisions.

<u>The Role in Inter-Divisional Communications of Third Parties External to the Firm</u>

Both customer agencies and vendors occasionally assume supporting roles in developing inter-divisional communications. Several engineers made reference to situations in which a vendor or the customer agency assumed the initiative for the first phase of communication; namely, identification of an individual or group performing work related to a given engineer's problem. One engineer described such an occurrence as follows:

> "Several times I've talked to vendors and they would say, 'Why don't you talk to somebody, perhaps in your own building see, he may be right here.' He says, 'He's working on the same kind of thing.' Or he might say, 'Call somebody at the XXX lab at the ZZZ Division.' There is no question that the vendors provide quite a bit of communication service in that way."

This "honeybee service" is also often performed by the representatives of government agencies acting in a customer role. This is particularly true during the initial stages of a development program. Usually, the customer agency will provide the group with relevant information on past work performed for it by both the present company and other contractors. Quite frequently, the R&D group will learn of relevant work performed in another division of their own company. Without the aforementioned "service," the group might not otherwise avail itself of the existing technical information.

CONCLUSIONS AND RECOMMENDATIONS

Armed with an impressive array of evidence showing the benefits of internal consulting and with an understanding of the fundamental reasons underlying the general reluctance to consult, what recommendations can be made to improve the situation? Blau (1963) and Shepard (1954) suggest an interesting possibility. Both of these analysts suggest an approach in which technical discussion sessions function to maximize gain while minimizing cost to the participants. Blau, for example, indicates:

> "The recognition of both participants in a consultation that one provided an intellectual service to the other raised the status of the consultant and subordinated or obligated the questioner to him. These were the inducements for the consultant to give advice, and simultaneously, the cost incurred by the questioner for receiving it. Discussions of interesting problems, on the other hand, were not recognized as providing a service to the speaker, and he did not start them because he experienced a need for <u>advice</u>. Manifestly, both he and the listeners, who sometimes commented, participated in these discussions because they were stimulating. The

> fact that they facilitated his solving of problems was disguised from the speaker as well as from his listeners; this was a latent function of such discussions.
>
> In the absence of awareness that a service was furnished, no need existed for the speaker to reciprocate for the help he did, in fact, obtain. He did not subordinate or obligate finding an audience, since interest in the problem and its solution supplied sufficient motivation for listening. This constituted the major advantage of consultations in disguise over direct consultations. We find ..., that the extraneous factors that motivate an interaction pattern that is not intended to, but does, fulfill a given function make it more efficient than a different pattern intended to fulfill this same function. Only a service intentionally rendered creates obligations, which make it costly." (p. 134)

Shepard, in describing the activities of a project group in a university affiliated laboratory, has this to add:

> "The exchange of technical information was a social act, with a significance in terms of interpersonal relations in addition to its significance as part of a body of knowledge. The greatest respect was reserved for those who had proved themselves competent in solving the most sophisticated problems. The provision of technical aid to those who had problems to solve was at once a sign of solidarity and a contribution to the system of reciprocated acts which kept the currency in circulation ... A series of exchanges in which everyone contributed technical information of equal value would result in the same relative statuses at the end of the series as at the beginning, but each member would be wealthier in terms of technical knowledge than before, and his status relate to members of other groups would be increased."

Technical discussions, in which all participants are able to make a contribution appear, then, to circumvent the dysfunctional aspects of social exchange underlying the consulting process. Seminars including engineers from several projects and from several functional areas can be organized around topics that will allow all participants to appear as equals. In this way, the status differential inherent in the consulting relationship can be avoided. While certainly members of the more sophisticated functional staff fact that they facilitated the delivery of programs was disguised from the speaker as well as from his listeners; this was a latent function of such circumstances.

In the absence of awareness that a service was furnished, no need existed for the speaker to reciprocate for the help he did, in fact, obtain. He did not elucidate or mitigate finding an audience, whose interest in the problem and its solution was the sufficient motivation for listening. This constituted the major advantage of consultations in this, the more direct reciprocation. We find [illegible], that the extraneous factors that motivate an interesting person [illegible] is [illegible] to but does [illegible] a given function here in each different than a [illegible] [illegible] same function. [illegible] [illegible] obligations, which [illegible]

Gerhard, in [illegible]

local interests, [illegible]

[illegible]

units (from which consultants would normally be drawn) should bring information of the more elegant variety concerning physical theory, mathematical techniques, and recent state of the art advances, the project members bring an equally important contribution in terms of specific new problems and applications. Since the inherent value ascribed by the technological community to these two types of information is somewhat out of proportion, management must assume responsibility for redressing the imbalance. The importance of information concerning the nature of current and future applied problems must be stressed, and the potential contribution of project team members to the work of functional staffs should also be stressed. The importance of the feedback loop which supplies problems to the functional research groups cannot be overemphasized.

Periodic seminars organized around specific problem areas or specific technologies in which management feels that the laboratory has particular competence hold promise then for improving the flow of information between technical specialists and project members. Such a device will, of course, not entirely eliminate the need for bi-lateral consultation. Unforeseen problems will arise and project members will have to seek assistance from staff specialists. The seminar program will undoubtedly assist this practice at least three ways. First, the seminars will increase the visibility of staff specialists. Very often, a project engineer will contact a source outside of his organization for information, simply because he is unaware of the expertise available within the organization. Second, the exchange process taking place within the seminar discussions diminishes the one-sided nature of later bilateral exchange. This results from the fact that the project engineer has demonstrated his ability to make a positive contribution to the knowledge of the specialist. When he later approaches the specialist for help, he is

first of all not unknown and, more importantly, he is recognized for his particular brand of competence. He is seen as a potential contributor and not as a pure information sink.

The third, and probably most important result will occur through the creation or strengthening of social bonds among the participants in the seminars. Previous evidence has shown the importance of simply knowing beforehand the individual from whom a person seeks help or advice. If the seminar program achieves nothing else, it will acquaint members of the laboratory staff who might not otherwise meet. This simple device of developing acquaintanceships will reduce the deterrents to bi-lateral communication within the organization .

Empirical support can be mustered for the seminar plan by referring once again to the study by Shilling and Bernard (1964), of 64 biological laboratories. Shilling and Bernard measured the extent to which informal technical discussion groups had formed in each laboratory. Specifically, they asked each respondent, "Are you a member of any group that informally discusses research"? They summarize the general finding in the following manner:

> "On the basis of a 50 percent participation criterion (50 percent or more of the respondents answering in the affirmative) it would seem that participation in group discussion is a custom in the scientific community; for example, in the median laboratory 60 percent of the scientists did participate in such groups. However, the great variability and the composite nature of the distribution suggests that the composition of the total set of laboratories may be blurring the picture . . .
>
> "Participation in discussion groups is clearly not part of the culture of the government laboratories; nor is it of the industrial laboratories. In none of these two types of laboratories did as many as half of the scientists report discussion group participation. In the other three types (private university,

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Replication [illegible]

[illegible]

public university, and private research institute), well over half did.

"The median private university and the median private research laboratory tended to show a larger proportion of their staff participating in such groups than the median public university laboratory. But among all three, it could clearly be said that group discussion was an established custom.

Because of the more bureaucratic organization of the industrial and government laboratories, it may be that taking time off for group discussion has not yet become recognized as a valuable scientific activity. In the universities, such discussion is part of a long academic tradition."

Shilling and Bernard, it will be remembered, found statistically significant correlations between the extent to which laboratory personnel participated in group discussions and seven of the eight measures of laboratory performance, which they employed.

Industry has often attempted to emulate and simulate the university atmosphere in dealing with its scientists and engineers. We see, for example, the campus-type facilities in which many corporations have invested. Kaplan (1965) has commented at length on this phenomenon and points out, they have for the most part operated on a false set of assumptions. Perhaps, we now have a situation in which industry could well profit by emulating an academic tradition.

In addition to the seminar program, management must take other steps to increase the general awareness of various laboratory activities and of information that is available within the laboratory organization. One possibility involves the formation of technical review panels. Frequently a research and development project will, at intervals be subjected to a management review, in which a panel, comprising members of the laboratory's management, is presented with evidence of the project's status in terms of costs, schedule, manpower and so on. An analagous technical review system might be established, in which the management panel is replaced by one composed of several of the lab's leading technical

specialists in appropriate areas, and the focus of the review is upon progress on the project's key technical problems. In this way, the staff specialists are brought directly into contact with the project team.

Of course in order to function properly, the project members must feel that they will not suffer for having revealed their problems. This is an essential point, and the success of the system rests entirely upon it. Should they feel that the revelation of problems will be held against them as evidence of incompetence, they will naturally conceal problems and frustrate the system. Project members must feel that they can trust the panel. To aid in attaining this goal at least two steps may be taken:

1. Members of management, above first-level supervision, would be excluded from the panel and from panel review sessions.

2. Project engineers must have a strong hand in the selection of panel membership.

The exclusion of management above the first level is an absolute necessity if project members are to feel that their future with the organization will not be affected by their candid revelation of technical problems. The second point supplements this. Election by project members would prevent the suspicion that the panel was a surrogate for management. On the other hand, management must have some voice in this selection process, if for no other reason than to insure against the election of friends who have no real claim to authority in the technical areas of concern, and of course, to exercise some control over the allocation of manpower in the laboratory.

Beyond this, there is a great deal of evidence,[10] that one of the most efficient mechanisms for the transfer of technology lies in the transfer of

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[10] In addition to the evidence presented here, the reader is referred to Roberts and Wainer (1967) for an interesting study of technology transfer from university laboratories to industry via the mechanism of spinning off technical entrepreneurs.

people. Systematic programs for the transfer of personnel among projects, functional areas and divisions should be instituted. Such programs could be incorporated with long-range manpower planning (an innovation in itself for most labs!), and could to some extent be handled by computer. Computers would operate on file data which in addition to the normal descriptive data, degrees, age, field, etc., would contain descriptions of each engineer's technical experience on a number of dimensions.

Three additional measures can be taken to encourage the use of bilateral consultation. First the organization's reward system should be restructured to reflect the importance of this activity. In other words, technical staff specialists should be rewarded for assisting the members of projects with their problems, as well as for work directly related to their own problems. Second, and this will be taken care of in part by the seminar program, engineers should be made aware that seeking consultation will in no way reflect on their own competence, but will be recognized as an attempt to increase competence by educating themselves. Both of these measures attack the costs associated with the social exchange transaction. In addition key individuals should be identified, who are not only knowledgeable in particular areas but who are capable of translating technical information to match the project engineer's needs, and their identitiy should be publicized in the lab.

Specific Recommendations

The principal conclusions and recommendations resulting from the present study can be summarized in the following four points:

1. Communication between R&D project members and other elements of the laboratory organization is very strongly related to technical performance on the project. This is true for both breadth and depth of communication. It is important not only to increase the extent of communication between project members and other key individuals in the organization, but also to increase the number of individuals with whom project members interact.

2. The psychological cost of using the internal consultant as an informatio source is relatively high when compared with certain other sources, as for example, consultants outside of the organization. Organizational remedies are available which will reduce elements of this cost, and these become readily apparent when one examines the strategies that are used for this purpose by engineers on an individual basis.

3. Group devices such as seminars and technical review panels should be developed not only to provide a basis for direct exchange of information, but more importantly, to provide a basis in terms of acquaintanceship and other such social ties for further communication beyond the device itself.

4. Programmed transfer of technical personnel within the laboratory and between divisional laboratories will, operating through the acquaintanceship mechanism, substantially reduce existing barriers to communication.

As a final point, it must be understood, that the implementation of any of these recommendations requires a high degree of informality. The one thing that became patently clear during the interviews was the general abhorrence by engineers of formality and management "red tape". The idea is not to force informal communication through the issuance of management directives but to create an atmosphere or organizational setting conducive to the development of the engineers' own informal communication network.

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