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AN INVESTIGATION INTO THE INFORMATION HABITS OF SCIENTISTS AND ENGINEERS IN INDUSTRY

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SPECIAL REPORT

by

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Assistant Director

AEROSPACE RESEARCH APPLICATIONS CENTER

October, 1969

Aerospace Research Applications Center
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Robert W. Hall
University of Tennessee
Sponsored by
Aerospace Research Applications Center
Indiana University
September 16, 1969

The Aerospace Research Applications Center (ARAC) is a non-profit technical information center operated by the Indiana University Foundation. It was among the earliest organizations to provide an operational technical information service to industry based on report literature collected and indexed by U.S. Government agencies. NASA was the primary agency involved in getting the center started in 1962, but in the seven years since then ARAC has expanded to provide services based on several sources of literature besides those sponsored by NASA. The primary sources are:

1. Scientific and Technical Aerospace Reports (NASA sponsored)
2. International Aerospace Abstracts (NASA sponsored)
3. U.S. Government Research and Development Reports (sponsored by the Department of Commerce)
4. Nuclear Science Abstracts (sponsored by the Atomic Energy Commission)
5. Engineering Index, (sponsored by the Engineers' Joint Council, not a federal agency)

The services of the center are all reading services, typified by the mailing of abstracts to interested readers who can obtain complete copies of reports they wish to read in full from the center. A very broad variety of technical topics is covered by the services of the center which can be classified in two ways. First, there are "current awareness services" which are mailings of recently released abstracts on either an ARAC-established topic area which the reader selects or on a topic which he defines for himself. "Current awareness services" come in several different varieties. Second is a problem review service which ARAC has labeled Retrospective Search Service, meaning that a specific, one-time problem submitted

by an individual in a client company is attacked by searching any available files of the center retrospectively back as far as they go. In addition, suggestions, referrals and personal contacts are frequently provided.

With services such as these, developing and maintaining communications with scientists and engineers who are likely to benefit both themselves and their companies by using the services is a continuing problem for ARAC. To learn more about the work habits and information source preferences of scientists and engineers in industry, ARAC sponsored this study.

Background of the Study

Studies of scientists and engineers are not new, of course, and this one starts from groundwork laid by several preceding ones. Several of the best studies into the information habits of scientists and engineers have been well summarized by Paisley,[1] and this work has started from the work of Thomas Allen at MIT[2] and from that of Allen and Gerstberger.[3] Allen found that individuals who acted as informal consultants within laboratories were likely to either read more technical literature than their colleagues, to have more extensive personal contacts outside the laboratory, or both. Consequently Allen called them "technological gatekeepers," a name that has become popular among research managers. The later Allen and Gerstberger study found that many engineers do not read mathematically complex articles, but in

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[1] William J. Paisley, "The Flow of Behavioral Science Information, A Review of the Literature," Report to the Committee of Information Processing in the Behavioral Sciences, National Academy of Sciences - National Research Council, done at the Institute for Communications Research, Stanford University, Menlo Park, California, Feb. 1966.

[2] Thomas J. Allen, Managing the Flow of Scientific and Technical Information, Ph.D. Dissertation, Sloan School of Management, MIT, Cambridge, Mass., Sept. 1966.

[3] Thomas J. Allen and Peter G. Gerstberger, "Criteria Used by Research and Development Engineers in the Selection of an Information Source," J. of Applied Psychology, Vol. 52, No. 4, August 1968, pp. 272-279.

opposition to what is claimed by many librarians, they do read, trade journals and less mathematical scientific articles making up their reading fare.

One other study contributed to the planning of this study. Maizell[4] studied the information habits of industrial chemists, comparing the habits of chemists rated "more creative" by their supervisors with the habits of those less "creative." He found that the more creative ones used a library more often, read more technical literature, were more likely to read complex or obscure articles, and were more likely to maintain their own indexes or collections of personal literature.

Purpose of the Study

The object of the study which was of most interest to ARAC was to compare three different types of individuals found in industrial research and development work with a control group on the basis of their information habits and a few personal characteristics that seemed reasonable to relate to their information habits. The control group was selected at random.

The definitions of the three groups to be compared are:

> Top Performers: The top ten percentile individuals resulting from a performance rating. This rating was conducted by a jury composed of a combination of peers and supervisors, and the criteria on which they judged performance emphasized individual value to the research and development function of the firm.
>
> Technological Gatekeepers: The top ten percentile of individuals selected by asking each person in the test population, "Please name three or four individuals with whom you most frequently discuss technical matters." That is, these individuals are the most popular informal consultants in their laboratories.
>
> ARAC Users: Persons who mentioned that they had used ARAC services and had found them to be of value. Five of the eleven were also technological gatekeepers.

The individuals tested were selected from four divisions of two major corporations. Sixty-five percent were engaged in aerospace contract R & D work.

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[4]Robert E. Maizell, "Information Gathering Patterns and Creativity," American Documentation, Vol. 11, No. 1, 1960, pp. 9-17.

A number of characteristics of the individuals were measured besides their information habits, but only two of these turned out to show significant enough differences to merit mentioning. They are:

> Technical Breadth: This was measured on a test listing forty technical topics and asked individuals to indicate their degree of familiarity with each. A higher score indicates greater familiarity with more topics.
>
> Remote Associates Test: This is a test for creativity measured by ability to make associations between three apparently unrelated words. It was developed by Sarnoff Mednick who defines creativity as "the forming of associative elements into new combinations which either meet specified requirements or are in some way useful."[5] It has been used for this purpose in a number of other studies. A higher score indicates greater creativity.

There were six different measures made of the information habits of persons in the different groups:

1. Preference rankings of 11 different sources of technical information.
2. Time spent reading 6 different types of literature.
3. Frequency of attendance at professional society meetings.
4. Frequency of using a library for job-related purposes.
5. Number of subjects on which each individual maintains an important personal literature collection.
6. Average number of useful sources of information which each individual has external to his own firm.

The results of this study have been used to suggest how corporations might adapt their organization to better use information centers such as ARAC which are external to the firm, and in fact, it is thought that the suggested change might improve the general flow of technical information within the R & D segment of the firm.

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[5] Sarnoff A. Mednick and Martha T. Mednick, Examiners Manual, Remote Associates Test, Houghton-Mifflin, New York, 1967, p. 1

Results of the Study

A great deal can be seen from looking at the composition of the groups. In Table 1 we see that lack of a degree is a prime reason for not being selected to be in one of the test groups. Ph.D.'s appear to predominate only in the technological gatekeeper group, and it seems that having a higher degree than most of the individuals around can contribute to being selected a gatekeeper. There seems to be little difference in age between the groups. In Table 2 we see that the majority of all three test groups are in supervisory positions of some kind, and the top performers have an especially large proportion of persons managing other

Table 1

EDUCATION LEVEL OF GROUPS TESTED

Group	Ph.D.	M.S.	B.S.	No Degree	Total	Average Age
Top Performers	1	6	16	2	25	35.0
Technological Gatekeepers	4	9	20	4	37	37.2
ARAC Users	1	1	8	1	11	36.8
Control Group	0	12	53	20	85	35.0

Table 2

SUPERVISORY LEVEL OF GROUPS TESTED

Group	Non-Management	Over Small Group	Over Other Managers	Total
Top Performers	8	9	8	25
Technological Gatekeepers	14	21	2	37
ARAC Users	5	4	2	11
Control Group	(No accurate data)			

managers while the gatekeeper group has a majority of small group leaders. In interviews several persons expressed the opinion that each small group leader should be a technological gatekeeper if he is doing his job properly.

In Table 3 the groups are compared on the basis of the measures of performance which were used in the study: (1) Performance rating by co-workers, (2) Papers published in the last 2 years, (3) Patents obtained in the last 5 years, and (4) Being cited by someone as having had "the best technical idea during the past year." The results of the Remote Associates Test for creativity and the 40-item test for technical breadth are also included. The results show that the top performers are patent producers, are significantly higher in generating ideas, are significantly higher in technical breadth, but are not significantly higher on the R.A.T. creativity score. The technological gatekeepers are above average in performance rating.

Table 3

PERFORMANCE CHARACTERISTICS OF GROUPS TESTED

Performance Characteristic	Top Performer	Technological Gatekeepers	ARAC Users	Control Group
Mean performance rating percentile	95%	77%	72%	45%
Average number of published papers per man	.28	.89	1.0	.29
Average patents per man	1.0	.40	.63	.31
Average number of citations from peers for having a "best technical idea during the past year"	1.20	1.75	1.11	.41
Average score on test to measure technical breadth	86.5	83.5	91.6	72.0
Average score on Remote Associates Test for creativity	13.3	15.0	17.7	12.8

(Only three were in the lower 50 percentile.) They also seem to be more paper producers than patent producers, are outstanding in the production of technical ideas, have significantly greater technical breadth, and a significantly higher R.A.T. creativity score. The ARAC users appear to be "super gatekeepers," excelling the gatekeepers in all areas except performance rating. The scores on the technical breadth test and the R.A.T. are phenomenal. (Two of the three highest scorers found on the R.A.T. are ARAC users.)

Two factors of note appear in Table 4. First, the technological gatekeepers and ARAC users rate government reports well ahead of the other two groups as preferred sources of technical information, and second the ARAC users are the only

Table 4

TECHNICAL INFORMATION SOURCE PREFERENCES OF GROUPS TESTED
(Ranked from most preferred to least preferred)

	Top Performers	Technological Gatekeepers	ARAC Users	Control Group
1.	Trade journals	Trade journals	Science journals	Trade journals
2.	Textbooks	Textbooks	Textbooks	Textbooks
3.	Science journals	Science journals	Trade journals	Science journals
4.	Company reports	Gov't reports	Gov't reports	Eng'rg catalogues
5.	Trade ads	Handbooks	Handbooks	Company reports
6.	Sales literature	Eng'rg catalogues	Company reports	Handbooks
7.	Gov't reports	Sales literature	Trade ads	Sales literature
8.	Handbooks	Company reports	Sales literature	Trade ads
9.	Eng'rg catalogues	Trade ads	Eng'rg catalogues	Sales Reps.
10.	Customer Reps.	Sales Reps.	Customer Reps.	Gov't reports
11.	Sales Reps.	Customer Reps.	Sales Reps.	Customer Reps.

group to prefer science journals over trade journals as their first choice information source. However, both the ARAC user and the gatekeepers cited more science journals than the other groups when asked to list their favorite technical journals. The implication of this is that the type of reading engendered by technical information services of the ARAC type is relatively difficult reading so that only the individuals inclined this way find the service to be of value.

It is surprising to see that the technological gatekeepers spend no more time reading than any of the other groups, as shown in Table 5, and they may spend less time. The only difference in the table which is significant is that the top performers spend more time than the control group reading company reports -- which is to be expected considering the number of upper level managers in the group. The ARAC users lead in reading the science journals -- the heavy reading category. Since both the top performers and the technological gatekeepers say that they spend no more time reading than the control group, but since they claim greater

Table 5

HOURS PER WEEK SPENT BY DIFFERENT GROUPS
READING SIX TYPES OF LITERATURE

	Top Performers	Technological Gatekeepers	ARAC Users	Control Group
Science journals	1.60	1.83	2.59	2.11
Trade journals	2.48	2.55	2.27	2.34
Company reports	2.42	2.01	1.63	1.55
Newspapers	4.76	4.66	4.73	4.73
Engineering catalogues	.56	1.40	1.65	1.38
Sales literature	.85	1.65	1.09	1.13

familiarity with a number of technical topics, their reading time must be more effective. Each group was also asked to estimate how many hours they spend on the job and how many hours they spend on job-related activity while at home, and the differences were not significant, thus indicating that these individuals are more efficient in the time that they do spend.

Table 6 shows the major differences in the usage different groups make of four separate sources of technical information. The major reason for the differences in number of professional meetings attended is that a fourth of the control group attends no meetings at all, while individuals in the test groups attend at least once a year. As expected the gatekeepers and ARAC users lead in the frequency with which they use the library, they are collectors of more literature and they have more information sources outside the corporation. (Note that the response by the ARAC users is biased because all of them were selected on the basis of citing ARAC in answering this question.)

Table 6

COMPARATIVE USAGE OF DIFFERENT INFORMATION SOURCES

	Top Performers	Technological Gatekeepers	ARAC Users	Control Group
Average professonial meetings attended per year	2.60	2.30	2.36	2.01
Approximate average times per month using library for job-related reasons	One	Two	Four	One
Average number of subjects for which individuals have a personal literature collection	2.40	3.43	4.18	2.55
Average number of technical information sources outside the corporation which are considered important	.92	1.21	2.27	.76

Implication of Study Findings for the Use of External Information Centers by Firms

The experience of ARAC during the past six years has been that in order for a large firm to effectively use the reading-oriented services, an informal arrangement must exist in the firm similar to the one shown in Figure 1. In smaller firms the same person may encompass two of the three functions shown. However, in all cases of successful and continued use of the services, these functions have been essential.

While about 85% of all firms who have started with ARAC services have continued them, those who have discontinued have stated reasons which usually fall into one of the two following categories:

1. The users did not find enough material of value to justify the time spent in reading abstracts. This can come from an honest mismatch in the technical interests of the individual and the subjects which the reading service covers, or it can arise from the user not feeling capable of reading difficult material.

2. The company was unable to find a method of promoting or coordinating the services within the company.

The number of ARAC users found is significant in itself. It is estimated that about 8% of the technical population of two firms who had standing arrangements with ARAC for several years actually found the service to be useful. This is not surprising because the type of reading is difficult, and this appears to be the proportion of the population that will be naturally attracted to it. Most technical information flow is transmitted by interpersonal communication -- as a number of studies, including Allen's[6] have found. Therefore, it is not reasonable to expect a large percentage of the potential using population to use a reading service. This seems just as true of internally developed services as external ones unless the nature of the reading is made easy enough that an unusual effort is not required.

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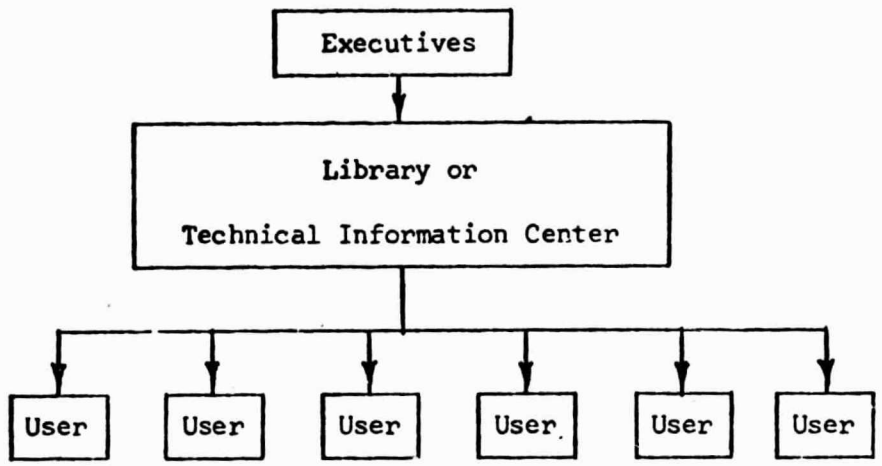
[6]Allen, Managing the Flow, Table 8-4.

Figure 1

INFORMAL ORGANIZATION STRUCTURE
EFFECTIVE IN USING EXTERNAL INFORMATION CENTERS



Function

An individual with authority must decide to expend corporate money and staff time using the services.

An interested, dedicated person or group must act as a service broker between the corporate R & D staff and the ARAC staff.

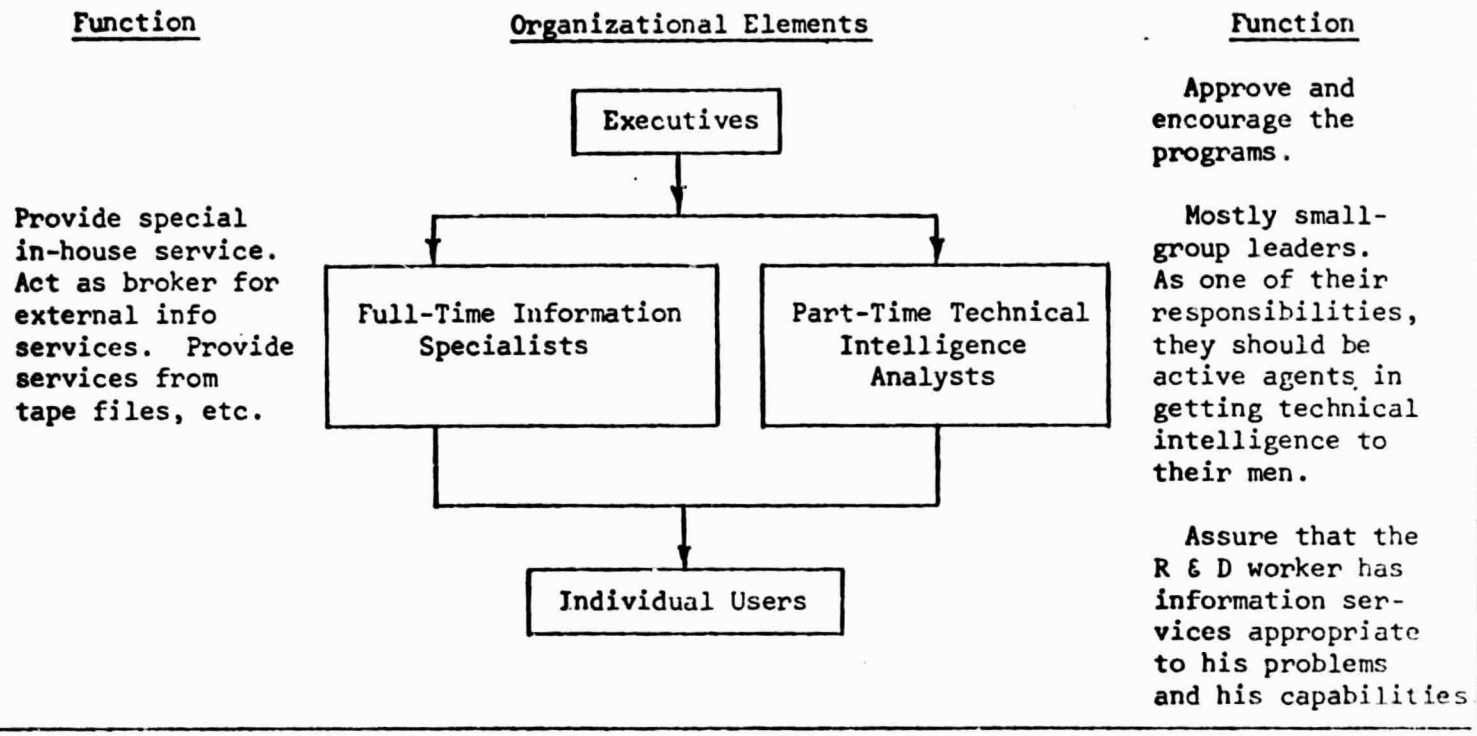
The ultimate recipients of services must be of appropriate type and be working at the leading edge of an appropriate technology.

The type of organization shown in Figure 1 appears to be essential for a firm to make minimal effective use of the types of information services which can be presented. This requires a level of effort which only those firms who aggressively pursue new sources of technical ideas will make. Those firms who wish to just let something happen find that little happens.

The type of organization structure given in Figure 2 is suggested as an improvement not only for a firm to use ARAC-type services, but to effectively promote external technical information flow into the research and development function of the firm. The core of the idea is to get key individuals on every project team of any size to act as "technical intelligence analysts" by having part of their duties consist of keeping up with literature and personal communications outside the firm which are related to the projects of the team. The key individual who does this would ideally be the group leader, but this depends on the nature of the particular group

Figure 2

PROPOSED INFORMAL ORGANIZATION STRUCTURE
FOR EFFECTIVE USE OF EXTERNAL INFORMATION SOURCES



leader. He may wish to have someone else take the responsibility. The important point is that someone on each project of consequence be formally charged with a technical intelligence function in connection with it. Of course, the type of person who fits this job is the one we have identified as the technological gatekeeper.

The function of this person would be to read, attend meetings and shows, talk to sales representatives and customer representatives, and perhaps occasionally make special trips to investigate the technology of outside organizations first hand. He would make himself available as an advisor to others on the project team, and part of his job would be to see that others on the team received the papers and publications that would be useful to them, and arrange for personal contacts that would be helpful to them.

In most R & D organizations this function is an individual responsibility, and certainly no measure should be taken which would restrict the freedom of the individual to do his own reading and set up his own discussions. The point is that when there is a wealth of information and information sources, someone should make it their business to see that each project is provided with a suitable level of technical intelligence, and what is everybody's business can sometimes turn out to have been nobody's business.

The project team or small group seems to be the appropriate level at which to focus attention on the information explosion. The ARAC experience has been that the key to providing a really useful information service is to know the work of a company very well. Computerized systems can help relieve the tedium from literature searching and reduce the time required, but they cannot replace the efforts of an individual who thinks in terms of matching what he sees against the technical problems which a company faces. Interpretation is a vital part of technical information flow, which is why so much of it is interpersonal, and the ARAC operation has been successful because this function has been provided by their staff when engaged in a problem analysis for client companies.

The information specialist in the private firm has largely been successful to the extent to which he could interpret technical literature in terms of what would be useful to his colleagues. A small number of information specialists cannot be expected to maintain a working knowledge of the projects of a large group of scientists and engineers. They are needed to provide the services which require special skill to provide, and they are wise to be as user oriented as possible, but it does not appear that they can do the job alone.

One company, Minnesota Mining and Manufacturing in Minneapolis is known to have instituted an organizational system resembling the plan suggested, but it is not yet known how it is working out.

The information problem is an expensive one to solve, and to date there appears to be no way around this. Proper dealings with technical information requires time and attention from key technical staff, and there appears to be little hope of improving this. There does appear to be hope that the effectiveness with which companies attack the technical information problem can be improved.