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FOREWORD

The Aerospace Research Applications Center (ARAC) at Indiana University was the first of a series of NASA-sponsored Regional Dissemination Centers (RDC) established at various points around the country. ARAC was started in December of 1962, and began operations with companies in April, 1963, as an experimental effort with two principal objectives. One objective was to devise a series of useful services in order to transfer NASA-related technology and innovations to private industry and thus reap further return from public monies spent on research and development. A second objective was to reach a point of acceptance by private industry such that all costs directly related to providing technology transfer services would be borne by the users of the services. The Center would then be self-sufficient and no further expenditure of public funds would be required to support activities directly related to providing technology transfer services to the Center's user firms.

ARAC, after nearly seven years of operational experience, has met both of these objectives to a large extent. The experiences of the Center in attaining the goals have been very varied in that the original conception of the Center involved a unique and novel cooperative effort between government, private industry, and the University. The entire concept of technology transfer was new and unknown at the start of the experiment. A good deal of effort was directed toward generally educating industry to the acceptance of the concept.

Fragmented accounts of this experimental effort are available in various quarterly progress reports submitted by the Center. However, no continuous and coherent write-up for this interesting experiment is available. This report is being prepared since ARAC has now reached a point in time when some conclusions can be drawn and an "historical" type document is both possible and called for.

It is anticipated that this report should be of interest to a variety of readers including persons interested in the technology transfer concept, persons whose work is primarily concerned with information science, and persons who are charged with the responsibility of operating information dissemination centers. The principal objective, however, is to document the results of significant ground-breaking experience in technology dissemination and transfer. To some extent each chapter in the report is written so that it may be read independently of the rest of the report. In particular, detail on the specific operations and products available from ARAC is included. For the sake of those readers who have a more general interest in the entire concept, much of the detail has been relegated to appendices whenever possible.

CHAPTER I: BENEFITS FOR THE HOST UNIVERSITY

Traditionally, the university has played three major roles. These are teaching, research, and service. In many instances the three roles have been inseparable. The classical service role of a university has been that of providing continuing education for the community, thus overlapping strongly with its teaching role. A number of progressive schools, particularly state supported institutions, have provided other kinds of services to the states, including participation in agricultural activities and compilation of business, tax, and manpower statistics for the various host states. A motivating reason for universities to participate in service activities is to maintain its image with the general public in much the same way business firms, and to some extent government organizations, have found this necessary. The establishment of a regional information center at a university is, therefore, an extension of philosophies that have existed with universities for a number of years. In particular, a technical information center located on a campus allows a channel of communication to be established between the university and the user industrial firms which had not existed before. This additional rapport with the industrial community seems to represent the most significant long range benefit to be derived in having a technical information center located on a university campus.

There exists, however, a number of more direct and immediate benefits to the university community through the presence of a technical information center than the one mentioned above. Universities, like other organizations, are currently feeling great pressure to improve their own internal management information systems. The kinds of expertise developed in the management and operation of a computerized technical information center are related and transferable to the problem situations which develop when a university attempts to install a reliable, low-cost management information system. The availability of this expertise on campus represents an important source which can be tapped as needed in the development of a good university management information system.

A university faculty can only be effective so long it is kept current in the various discipline subject areas with which the faculty members are concerned. Traditionally, the responsibility to stay current has fallen entirely to the faculty members. Historically, a faculty member has maintained his currency by personal correspondence with peers who have similar interests in his own and other institutions, by subscription to several technical journals in his discipline, and by a certain amount of browsing through the general university library or in a special library. Technical information centers located on the campus provide a potentially strong and important mechanism for a faculty member and his graduate research assistants to be kept current in their particular field of interest since the services of the information center may be entirely appropriate to their interests even though they were specifically developed for industrial users. It is worthy of note that the content of the NASA information resource represents a number of documents larger than the holdings of many American college and university libraries.

Many universities are currently in the process of attempting to automate, at least in part, their libraries. An additional thrust is being made to expand the services available from university libraries and to make them more timely, more economical, and more user oriented. Many of these objectives toward library automation are identical to the goals of a computerized information center located on the campus. Once again, the availability of the expertise at the Center represents a resource which can be tapped as needed by the library system of the university in its efforts to upgrade and automate the functions of the library. Additionally, the technology collection of the university-based information center serves to enhance and supplement the conventional university library holdings.

The prowess of a university as a high quality research institution can gain in stature only so long as the university is able to attract high quality graduate students to participate in its various professional degree programs and the research associated with the earning of these degrees. Typically, insufficient funds are available at universities to support the high quality graduate students who might be interested in pursuing an advanced degree and in performing the associated research. In the operation of ARAC it has been found that graduate students seeking advanced degrees represent an important and highly skilled labor pool whose talents can be used in a most effective manner toward fulfilling the mission and providing the services of a technical information center. At the same time, the offering of assistantships to qualified graduate students by ARAC helps fulfill an important mission of the university because additional graduate students can be supported beyond what had normally been planned with university funds available for this purpose. In recent years the majority of funds available from Federal granting agencies for support of graduate students has been in the more technical disciplines such as chemistry, physics, geology, etc. Thus, the Federal granting agencies have favored the granting of graduate assistantships to hard science applicants while assistantships available to students in humanities, business, law, education, etc. had fallen to a low level. Because of this ARAC found that it was difficult to attract qualified graduate students pursuing professional degrees in technical disciplines to work with the Center. At the same time graduate students interested in pursuing professional degrees in non-technical areas represented very likely candidates for furtherment of the ARAC objectives. Thus, the kind of person sought by ARAC to fulfill this capacity was a person who had at least a bachelor's degree in a technical subject, had worked several years in industry, and was now interested in pursuing a professional degree in a non-technical area. It was found that there existed an abundance of candidates who met these qualifications. Through the first seven years of operation ARAC had used some 117 graduate students in the capacity of engineering information analysts on a half-time basis while pursuing their advanced degrees. Since these information analysts were paid at a rate commensurate with the professional performance expected of them in their ARAC capacity, the ARAC assistantships were highly sought after. As such, these positions have been filled throughout the entire ARAC history with only top-notch candidates. By working with ARAC on a half-time basis while pursuing a non-technical professional degree, these persons had the opportunity to stay current in their technical areas because of their daily reviews of the new information appearing in the various disciplines. Additionally, when graduation came for these people, prospective employers considered the time spent with ARAC to be a very valuable work experience and, as such, graduate students who held ARAC assistantships have become the most highly sought after and, incidentally, most well-paid new job applicants. It should be mentioned, however, that a part of this was built in since they were already top-notch candidates in their fields prior to their work experience with ARAC.

In summary, it may definitely be stated that significant benefits have accrued to the University in hosting the ARAC technical information center. The advantages have not been entirely unidirectional. In the early stages alumni and friends of Indiana University played significant roles in establishing the working arrangements with the original charter member companies of ARAC. Throughout the history of the Center, the administration, faculty, and graduate students have been a vital source of guidance and manpower to ARAC. It would appear that in many respects the operation of ARAC as a university-based Center could serve as a textbook example of organizational symbiosis.

CHAPTER II: INFORMATION REQUIREMENTS OF INDUSTRIAL SCIENTISTS AND ENGINEERS

In recent years many studies have been undertaken in an attempt to understand and better manage the information habits, information flow, and the attendant innovation supposedly commensurate with good management of the information resource. This chapter will present a summary of the current hypotheses with regard to information flow in research laboratories, information habits of scientists and engineers in industry with regard to ARAC services, and some viewpoints of industrial R & D managers.

INFORMATION FLOW IN RESEARCH LABORATORIES

This portion of the report is based on a paper written by Thomas J. Allen and Stephen I. Cohen entitled "Information Flow in an R & D Laboratory," August, 1966. It is included as introductory material for the next section which discusses the relationship of ARAC services to information habits of industrial scientists and engineers.

Some studies[1,2] of industrial and government scientists and engineers have shown an inverse relation between extra-organizational communication, contrasting with a direct relation between intra-organizational communication, and performance. A related study[3] of academic scientists in which the organization appears to occupy a subsidiary position to a more inclusive social system, (and where the communication process measured was external to the first entity but internal to the second) shows a strong positive relation between the extent of communication and performance. Moreover, in the instances in which external communication bears an unfruitful relation to performance, there is evidence that it is not this communication, per se, which degrades performance but other factors, such as lack of necessary knowledge on the part of the engineer or scientist seeking information. The internal channels are better able to compensate for this deficiency, than are external ones.

In industrial and governmental situations, the laboratory organization dominates the scene. In addition, the members of industrial and governmental organizations acquire through common experience, and organizational imposition, shared coding schemes or common ways of ordering the world, that can be quite different from the schemes held by other members of their particular discipline. This is not true, for example, of academic scientists. They generally feel more aligned with scientists who share their peculiar research interests than with a particular university or department, and would therefore tend to share a common system of coding with such individuals outside of their department.

The mismatch problem is compounded when, as is often the case, incompatibilities between the two coding schemes go unrecognized, or when identical coding systems which do not in fact exist are assumed.

There are, of course, possible measures that can be applied to reduce the organizational boundary impedance. One that may well take place under uncontrolled circumstances is a two-step process, analogous to that found in public opinion research, in which certain key individuals act as bridges linking the organization members to the outside world. Information then enters the organization most efficiently when it is channeled through these individuals, who are capable of operating within and translating between two coding schemes.

The possibility that such individuals exist, who in effect straddle the coding system and are able to function efficiently in both, and perform a transformation between them, holds promise for their potential utilization in information transfer. It is pertinent to address this problem directly by examining the flow of information both into and within the confines of a research organization. Before turning directly to this problem a brief review of a large body of research devoted to the examination of the flow of information in a somewhat different context is presented.

Public Opinion Research

Twenty-five years ago, in order to explain a phenomenon which had been observed in a study of popular decision-making during the course of the 1940 election campaign, a study[4] revealed what has become known as the two-step information flow hypothesis. It appeared that ideas flow from radio and print to opinion leaders and from them to the remainder of the population. In a subsequent study,[5] a major hypothesis was built around this "two-step" process and was able to marshall considerable support. Instead of a simple direct connection between mass media and the general public, the process was discovered to be more complex and to involve a number of intervening variables. Furthermore, the intervening variables (e.g., relative composure; channel preference; the effect of message content; attitudes and psychological predispositions of the audience) all involve the individual's social attachments to other people, and the character of the opinions and activities which he shares with them. Thus, the response of an individual to a communicated message could not be accounted for without reference to his social environment and to the character of his interpersonal relations. This two-step flow was found to be mediated by "opinion leaders" who in every stratum of society perform a relay function: controlling the flow, for example, of political information from mass media to electorate, and thus influencing the vote. It was found that the opinion leaders were considerably more exposed than the rest of the population to the formal media of communication. As a result, this study argued that "ideas flow from radio and print to opinion leaders and from these to the less active sections of the population."

Specifically, it was found that "leaders in a given sphere (fashions, public affairs, etc.) were more likely to be exposed to the media appropriate to that sphere."[6] In addition to mass media exposure, influentials tend to have a greater number of interpersonal contacts outside of their own groups. Thus, in a study[7] of drug adoption by physicians, it was discovered that the more influential doctors were characterized not only by greater attention to medical journals, but also by more frequent attendance at out-of-town meetings and the diversity of places with which they maintained contact. Similarly in studies[8] of the adoption of such innovations as hybrid seed corn, it was concluded that opinion leaders, in this instance, can be characterized in terms of the relative frequency of their trips out of town, and in a general predisposition toward "cosmopolitanism."

Relation to the Flow of Technology

The most obvious illustrative relationship between the flow of scientific and technological information and the studies discussed above would appear to be through the studies of the adoption of agricultural and other innovations. The qualitative nature of the information being exchanged is certainly more akin to the type of information which concerns this report, than is, for example, the information contained in communications which influence a person's vote or his choice of food or fashions. The results of such studies have been well summarized.[8] There is certainly a clear analogy between transfer of information in societal utilization, and our present concern, the transfer of information from science to technology or from one organization to another within science or technology. Nevertheless, there is much that can be learned from the mass communications studies that will be of value in better understanding the process of technological information flow.

Several studies[5,8] have stressed the importance of the individual's face-to-face relations in transferring information of these two diverse types. Some investigators claim that their studies have led them to "rediscover" the significance of the primary group in its normal sociological context. There is quite clearly a parallel in the research and development laboratory. Strong evidence has been found that engineers are not very closely connected to the formal communication media, and that they rely much more heavily upon oral channels. There is also some evidence from Allen's studies that other members of the engineer's immediate work group or colleagues and friends in other parts of the organization are often instrumental in delivering information to him, or making him aware of the existence of a particular source. Repeatedly, when the researchers attempted to determine the source of a particular idea, it turned out that no single source was responsible, but rather that several sources contributed to the discovery or formulation. In one case, an engineer's colleague hears a paper delivered at an SAE conference, associates the device described with a problem which the engineer has and tells him about it. The engineer, himself, follows up the lead, searches the literature, contacts the man who delivered the paper, and gets in touch with a vendor who can supply some of the hardware. Another case is quite similar. A vendor visits a particular engineer, and tells him about a new piece of equipment which his company has developed. The engineer knows of a colleague to whose problem this equipment might be relevant. He suggests that the vendor contact his friend; the vendor does, and the application is found appropriate.

These instances are stated exactly as they were related to the interviewer, and they are not isolated occurrences. Very frequently a mediator either directly relates information which he has obtained from another source, or indirectly assists in the transaction. The evidence from the parallel studies is sufficient to at least indicate the possibility of a two-step flow in technological communication.

The Hypotheses

Two major hypotheses have been generated based upon the findings of earlier studies in mass communication, and upon other research on information flow.

1. Technological gatekeepers. There can exist in an R & D laboratory certain key individuals who are capable of effectively bridging the organizational boundary impedance and who provide the most effective entry point for ideas into the lab. These gatekeepers will be characterized in three ways:

    a. They will be the people to whom others in the lab most frequently turn for technical advice and consultation.

    b. They, themselves, will be more exposed (than others in the lab), to such formal media as the scientific and technological literature.

    c. In addition to exposure to formal media, the gatekeepers will maintain a greater degree of informal contact with members of the scientific/technological community outside of their own laboratory.

2. The influence of the primary group. The role of the primary group in mediating information flow will be manifested in two ways:

    a. Communication patterns will tend to follow the structure of both the formal work group structures and the informal social relationships in the laboratory.

    b. Technological attitudes, attitudes towards such things as feasibility of particular approaches which are not yet physically testable, will be strongly influenced by the attitudes held by other members of the primary groups to which the engineer belongs.*

Conclusions

The validity of these two hypotheses may be tested by conducting sociometric studies of interpersonal relations and information flow in R & D laboratories. Questionnaires and personal interviews are normally used to ascertain the interrelationship. The results of recent research

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*This hypothesis is, of course, directly attributable to the thinking of Kurt Lewin and his followers, who proposed that when an opinion or attitude cannot be tested directly against "physical reality" that the individual will resort to a test against "social reality." In other words, he will look to his peers for confirmation or disconfirmation and react accordingly. This is now a concept which is treated in some detail in most Social Psychology textbooks, see for example, Newcomb, Turner, and Converse (1965), p. 234. The present hypothesis merely extends this line of reasoning into an area where attitudes are usually, but not always accessible to physical testing.

provide substantial support for the two hypotheses concerned with the gatekeeper and the role of primary groups. There definitely appear to exist in labs studied, technological gatekeepers, people to whom others turn for technical discussion and consultation, and who, in turn, report having a greater amount of contact with the professional and scientific literature or with technically trained friends outside the lab. In addition, people are found who were responsible for introducing into the lab what were almost unanimously agreed upon by the respondents as the most important ideas during the previous year. These people are well above the average in their use of the literature and of interpersonal contacts outside of the organization as sources of technical information.

The complete and distinct relay personality does not, however, appear. Rather, there are varieties of people who are capable of performing the relay function. Some operate better translating from the literature; others from oral sources. Opinion leaders in the present context are not of a monolithic sort. They vary considerably in the nature of the sources from which they derive information and quite possibly in the functions for which their transmitted information is used.

The situation described in the preceding paragraph is not unlike that discovered in mass communication research. In that context, opinion leaders were found to be differentiated by topic; those who were influential in public affairs were not necessarily influential in determining fashion patterns, and so on. Moreover, the nature of the area of influence was found to be related to media exposure.

When medium content was taken into account, it was found (at a more detailed level of analysis) that movie leaders read movie magazines more, public affairs leaders read more news magazines, fashion leaders more fashion magazines, and so on, suggesting that a more detailed look should be taken at the content of the messages processed by the various gatekeepers in R & D laboratories. It is implied that the selection of channels (e.g., literature vs. external oral sources) by scientific and technological gatekeepers may be based upon the qualitative nature of the information in which the gatekeeper specializes, and that channels vary in their ability to provide different types of information. As an example, the literature has been shown to provide information which is important for keeping abreast of the state of a technological field, while oral sources are probably better in providing more specific detailed information about particular techniques, especially on current technical problems which require immediate attention. Gatekeepers who specialize in knowledge of the state-of-the-art would then tend to expose themselves more to the literature, while those specializing in particular research techniques would interact more with external oral sources.

It has been shown that a finer differentiation of channel information content can make some difference in data interpretation from sociometric studies. When Ph.D.'s are compared on the basis of number of periodicals read regularly with non-Ph.D.'s, the difference between those who are most frequently sought for technical discussion and those who are not, is somewhat less than when they are compared on the basis of a particular subset of periodicals (scientific and professional journals).

In terms of improving the effectiveness of ARAC operations with companies, an important piece of research had to be undertaken. Specifically, research had to be done which was concerned with a finer distinction among channels and information content and which should attempt to determine the characteristics which distinguish different types of gatekeepers. The latter goal has an important implication for management, since its attainment would allow the identification of these individuals who are the key nodes in the transfer of various kinds of information within the laboratory.

INFORMATION HABITS: RELATIONSHIP TO ARAC SERVICES

This section of the report describes some research done at ARAC for the purpose of defining the relationship between technological gatekeepers in industrial firms and the value of ARAC services. The purpose of the research in part was to illustrate the relationship, if any, between those who use ARAC services in industrial firms and technological gatekeepers.

The Aerospace Research Applications Center 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 available to ARAC at present are:

1. Scientific and Technical Aerospace Reports (NASA developed)

2. International Aerospace Abstracts (NASA sponsored)

3. U. S. Government Research and Development Reports (developed by the Department of Commerce)

4. Nuclear Science Abstracts (developed by the Atomic Energy Commission)

5. Engineering Index (sponsored by the Engineer's Joint Council, not a Federal agency)

6. Resources available through the NASA Regional Dissemination Center (RDC) network. Presently these include access to Chemical Abstracts CONDENSATES file, textile file, and metallurgical file.

The services of the Center are 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 as far back 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 undertook a study described briefly in the following sections.

Background of the Study

The groundwork for the ARAC study was laid by several preceding ones and principally by the work of Thomas and Allen described briefly in the preceding section. It has been found that individuals who act 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, they were labeled "technological gatekeepers," a name that has become popular among research managers. A later study[9] found that many engineers do not read mathematically complex articles, but in opposition to what is claimed by many librarians, they do read. Trade journals and less mathematical scientific articles make up their reading fare.

One other study[10] contributed to the planning of this work which involved the information habits of industrial chemists, comparing the habits of chemists rated "more creative" by their supervisors with the habits of those "less creative." Maizell 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 compared were:

> 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.

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." 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.

Results of the Study

A great deal can be seen from looking at the composition of the groups. In Table 2.1 we see that lack of a degree is a prime reason

Table 2.1

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 2.2

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)			

Table 2.3

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

Table 2.3 (Continued)

Performance Characteristic	Top Performer	Technological Gatekeepers	ARAC Users	Control Group
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

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 2.2 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 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 2.3 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. (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 excelled the other 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 scores found on the R.A.T. are ARAC users.)

Two factors of note appear in Table 2.4. First, the technological gatekeepers and ARAC users rate government reports well ahead of the two other groups as preferred sources of technical information, and second, the ARAC users are the only group to prefer science journals as their first choice information source. However, both the ARAC user and the gatekeepers

Table 2.4

TECHNICAL INFORMATION SOURCE PREFERENCES OF GROUPS TESTED
(Ranked from most preferred to least preferred and not differentiated for problem solving or current awareness)

	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 catalogs
5.	Trade ads	Handbooks	Handbooks	Company reports
6.	Sales literature	Eng'rg catalogs	Company reports	Handbooks
7.	Gov't reports	Sales literature	Trade ads	Sales literature
8.	Handbooks	Company reports	Sales literature	Trade ads
9.	Eng'rg catalogs	Trade ads	Eng'rg catalogs	Sales reps.
10.	Customer reps.	Sales reps.	Customer reps.	Gov't reports
11.	Sales reps.	Customer reps.	Sales reps.	Customer reps.

Table 2.5

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 catalogs	.56	1.40	1.65	1.38
Sales literature	.85	1.65	1.09	1.13

cited more science journals than the other groups when asked to list their favorite technical journals. One possible implication of this is that the type of reading engendered by technical information services of the ARAC type is relatively difficult reading so that the individuals inclined this way find the services to be of greatest 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 2.5, 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. This is possibly due to the nature of ARAC users. 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 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 2.6 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 the 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 2.6

COMPARATIVE USAGE OF DIFFERENT INFORMATION SOURCES

	Top Performers	Technological Gatekeepers	ARAC Users	Control Group
Average professional 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 info. 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 Firm

The experience of ARAC during the past seven 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 2.1. In smaller firms the same person may encompass two of the three functions shown. A detailed discussion of phenomena observed in working with smaller firms is presented in Chapter V. 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 in a firm is significant in itself. It is estimated that about 8% of the technical population of the two firms (who had standing arrangements with ARAC for several years) actually found the services to be useful. In both firms studied, between 10% and 15% of the technical population used ARAC services, thus the 8% represents a majority of the users. 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 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.

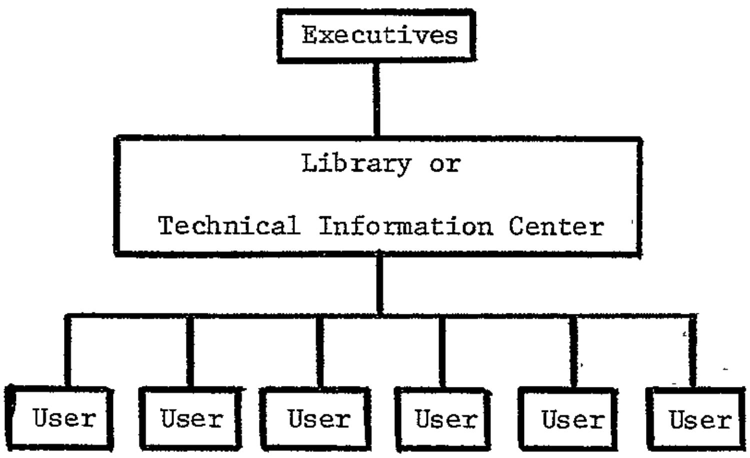
The type of organization shown in Figure 2.1 appears to be essential for a firm to make minimal effective use of the types of information services which can be presented. This requires a level of effort which only those firms who aggressively pursue new sources of technical ideas will make. Those firms who wish to just let something happen find that little happens.

The type of organization structure given in Figure 2.2 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

Figure 2.1

INFORMAL ORGANIZATION STRUCTURE
EFFECTIVE IN USING EXTERNAL INFORMATION CENTERS

Organizational Element



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.

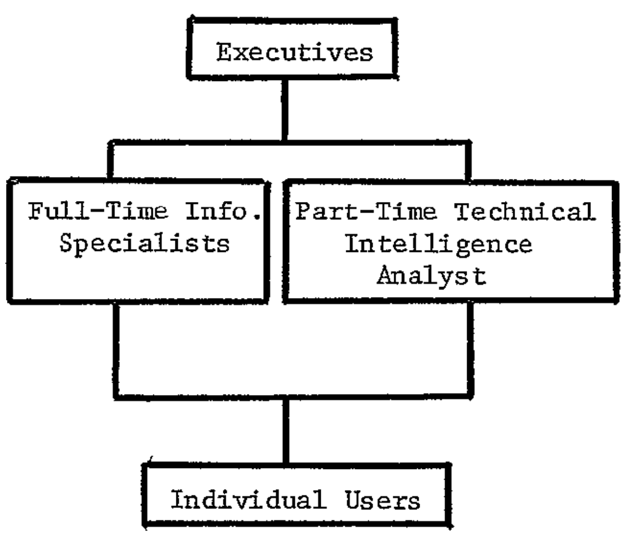
Figure 2.2

PROPOSED INFORMAL ORGANIZATION STRUCTURE
FOR EFFECTIVE USE OF EXTERNAL INFORMATION SOURCES

Function

Provide special in-house service. Act as broker for external info. services. Provide services from tape files, etc.

Organizational Elements



Function

Approve and encourage the programs.

Mostly small-group leaders. responsibilities, they should be active agents in getting technical intelligence to their men.

Assure that the R & D worker has information services appropriate to his problems and his capabilities.

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 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 previously 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 receive 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 his business to see that each project is provided with a suitable level of technical intelligence.

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 information flow, which is why so much of it is interpersonal. The ARAC operation has experienced some success because this function has been provided by its staff when engaged in a problem analysis for client companies.

The information specialist in the private firm has been successful only to the extent of his capability to 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, 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 utilization of 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.

INDUSTRIAL MANAGERIAL ATTITUDES

Any discussion of technology transfer and economic growth must necessarily involve the activities of the business community. Economic growth and business activities are inseparable; the rate of growth is dependent on the rate at which technology can be converted to goods and services. American industry's record is very good. But, the challenge now is to improve the process in the face of vastly greater complexities, resulting from almost limitless choices, coupled with an accelerated pace of change.

Most economists agree that the elapsed time between the inception of new scientific ideas and their emergence in the form of useful products is steadily decreasing. For example, the principle of photography was known for over a century before the first camera was produced. It required fifty-six years to develop the telephone, but only thirteen years to develop the commercial use of atomic power; five years for the transistor, and three years for the laser. The so-called invention industry now seems to rival the automobile industry in size. In other words, government and privately financed research, development and testing comprise one of the biggest industries in our society.

Federal government budget figures may be used to emphasize how fast this invention industry is growing. The 15 billion dollars expended by the Federal government in 1966, was double the outlay of 1960, triple the amount of 1958, and fifteen times greater than that in 1950. This vast technological complex has been one of the main underpinnings of the remarkable economic expansion recently experienced.

However, it must be cautioned that the sheer proliferation of technology is imposing some serious limitations on industry's continued ability to absorb and to use new knowledge. Oscar L. Dunn, vice president, General Electric Company, estimates that the growth rate of knowledge in the world's libraries is two million bits per second. He further estimates that the human mind can only absorb one hundred bits of new knowledge per second. This gap is created to a large extent by the computer and new high-speed communications equipment. It is to the improved uses of such pieces of equipment that we must hopefully look for help. The point is some business managers haven't changed their own "circuitry" very much during this time. Managers must do a better job of tuning in on some of the new developments in the future, to get the most out of them. In some technologically complex areas, the computer has already helped enormously in the developments of markets faster than had been thought possible.

On many sides, business has only begun the task of using new technology. In our troubled cities, in raising the quality of life, the problem is not a dearth of ideas and designs, but a lack of new and imaginative ways to employ them. If we were to look at the task of a technologically oriented business fifty years ago, we might say that it was to build a better mousetrap, or to design a better piece of machinery. The task confronting business now is to design solutions to our problems, which will make the most effective use of machines and techniques that we already have.

Full utilization of technology must have as its goal economic growth through both the discovery of new products and services useful to mankind and the improvement of existing products and services. To achieve this goal in our economy it is, of course, mandatory to transfer to production, and thence to sales, as much as possible of the technological accumulation of R & D, whether it be technology developed by R & D through in-house work, or external information coming to the attention of R & D personnel during the course of their work. Only in this way can this technology be useful. It is this transfer from R & D to production which is too often the missing link.

The importance of successful transfer is emphasized by the very nature of R & D. G. H. Stemple, research center administrator of the General Tire and Rubber Company, estimates the expectation of success in R & D projects in the neighborhood of five to fifteen per cent. If the promising projects as they appear are not carefully nurtured and carried to the fruition of production and sales, then R & D can become a costly luxury which business cannot afford. It should not be implied that all data from projects not commercially successful are useless. But any given company can afford to pay for only a limited amount of such data.

Unfortunately, there are many shiny nuggets buried in R & D notes that may never be utilized simply because the magic formula to convert them to commercial products is wanting. Generally speaking, there are two kinds of information coming from R & D which must be carefully analyzed for possible commercial use: First, research information resulting from work which had no product objective in mind (some companies call this pure, basic, or long-range research); and second, information from projects carefully selected to meet a definite commercial goal (some companies call this applied or directed research). Development projects, if properly selected, are more easily understood and assimilated, pose an additional problem in that the scientist or engineer interested in research frequently derives his primary satisfaction from discovering new materials, processes, knowledge, etc. Though not opposed to their use for profit, he may have neither the inclination nor the background to search for practical applications of his work. One of the steps in technological development requiring the most imagination is that of finding possible practical uses for a completely new concept. It must be remembered that such entirely new concepts may lead to a most favorable competitive position and a real breakthrough in profits.

At the same time, one must not overlook the possibility that development information obtained in the solution of a specific problem for an imminent production item may lead to a completely new and different concept resulting in an unexpected breakthrough. The search for the recognition of such opportunities requires a rare combination of power of observation, freedom from thought control by past art, and imagination.

Let us consider the problem of transferring R & D information to production. Evidence that a problem exists is perhaps best attested by the great strides made in the utilization of technology in times of stress. There is perhaps no better example than the phenomenal growth of the synthetic rubber industry following the capture of the majority of the natural rubber producing areas of the Far East by the Japanese in 1942. So successful has this development been that we now have available not only a synthetic rubber exactly equivalent to natural rubber, but also many new rubbers which perform under conditions that natural rubber cannot tolerate. Yet the essential technology to produce a rubber quite satisfactory for small tire use was available and waiting to be used in the middle thirties before the war started.

Basically, this transfer of information from R & D to production is a sales problem and involves all of the elements that enter into any good sales promotion such as good communications, careful education, good inter-group relations, and enlightened leadership. No matter how good the technology, it is essential that production be completely sold, for in final analysis, the word of production people will necessarily carry great weight in management's decision whether or not to proceed in production with a given project. While developing such a sales program, it must be realized that R & D and production personnel have different training, inclination, and professional goals. Stated simply, R & D has the responsibility of seeking change: new or improved products. Production, on the other hand, is charged with the responsibility of maintaining status quo: to produce a product which day after day meets rigid quality control and cost specifications on which sales can unquestioningly depend. Reticence to change any part of production procedure is readily understood when one considers that deficiencies in the product often do not begin to show up for a matter of months after the product is in the hands of the customer. The interim production may then represent a serious liability. Furthermore, production must operate in a rigid time frame, and deviations are costly and to be avoided; whereas the very nature of R & D precludes the possibility of rigid time schedules.

The difference in general attitudes of R & D and production people require that a much more real and personal relationship be established between the parties involved in technology transfer. Several positive actions can be taken to help maintain the proper atmosphere. The choice of which action or actions to take will necessarily depend on the characteristics of the people available. A few of these courses of action are:

1. Top management's desire for new products must be unequivocally passed down the ranks. Division management must be allowed to take the risk necessary to start new products and must understand that they will get special credit for starting successful new products.

2. Stearing committees made up of technical people from R & D, production, and sales may be established to monitor work in specific areas of company needs. There must be strong committees with management backing to spend the time required for full understanding of the problems and the methods used to attack the

problems. The stimulating effects of basic research scientists and engineers on such committees should not be underestimated.

3. Various committees composed of both management and technical people, and sometimes sales people as well, may be utilized to consider the overall R & D proposals and help select suitable projects. Such committees frequently become ineffective rubber stamps, unfortunately, because the non-technical people involved simply do not have the understanding or the time required to master the job at hand.

4. An overall technical director may be appointed to consider all technical problems including both R & D and production development. He must have enough stature to be able to sell his conclusions to production and to management. He should have sufficient background that he can fully comprehend the language of both R & D and production, and sufficient time to dig into what is going on in R & D to be sure nothing is overlooked. This requires an individual with a rare combination of talents.

5. Periodic company-wide R & D and Production technical meetings may be used to keep these people informed of the work being done both in production development and in R & D, and to generate a real acquaintanceship among these people. It is very important that R & D personnel promoting a project be as well acquainted as possible with the people "buying" the project, and vice versa. Such meetings also serve to condition the production people so that an imminent new product idea does not appear quite so new, and hence so scary, when it reaches production.

6. A firm must have an organized method for keeping its R & D personnel informed of recent developments internal and external to the firm. New information and technology represents a resource which firms should actively pursue and tap as appropriate. The sheer abundance of new information precludes leaving this important function to chance. The presence of an in-firm person knowledgeable about the firm's information needs cooperating closely with an outside organization that specializes in the location of new and relevant information represents the minimum essential requirements.

CHAPTER III: TECHNOLOGY TRANSFER SYSTEMS

A basic consideration in the formulation and design of technology transfer systems has been that of developing a close and continuous linkage between the information base and the scientists and engineers in each participating industrial firm. There are two factors which complicate the task. First, there is a continuous inflow of new scientific and technical information. Second, only information relevant to company interests, needs, and problems must be drawn from the expanding store of knowledge. The objective is to build an effective communication network through which elements from the broad base of technology can be selected and matched to specific company needs and interests. The Center's information base is made up of over 700,000 technical reports. Each month over 15,000 new reports are added from NASA, DOD, AEC, and other government and non-government sources. In total, the information base covers a broad spectrum of science and technology.

A man-machine systems approach has been utilized in connecting the information base to the technical people in individual firms via ARAC as an information intermediary. Among the most important elements in the transfer task are the Center's staff engineers and scientists. They are specialists with backgrounds and experience covering a broad range of science and technology from metallurgy to medical science. This team develops continuous working relationships with the technical people in each company. The ARAC staff is able to understand, interpret, and contribute to the solution of industrial problems. With a detailed understanding of the technology and its application to company needs and interests, staff members can effectively screen and identify relevant information. These people are a vital link in the transfer chain.

The staff is composed in most part of graduate students. These people are competent professionals with educational backgrounds in science or engineering and industrial experience ranging from one to ten years. The typical ARAC staff engineer has returned to the University for graduate study after spending two to four years in industry. Staff members are carefully selected to assure top academic performance plus a solid base of industrial experience in various scientific and technical areas.

The Center provides these people an unusual opportunity to keep abreast of their technical fields during the time they are working on advanced degrees. Many of the staff will move back into industry holding positions similar to those held by the company technical people with whom they have been working. Regardless of their area of industrial interest, these men take with them a real appreciation and proficiency in the use of information in helping to solve industrial problems. The relationship involves a two-way flow of benefits. The technical staff provides the Center with a wide range of scientific and technical competence. The staff gains an important exposure to emerging technology, concepts and techniques for information transfer, and experience with a broad range of industrial problems.

A computerized information retrieval system forms the remaining part of the man-machine information system which links the industrial firm with the knowledge base utilized by the Center. The computer is a vital part of the total system. The search system can seek information on twenty-five different problems from a file containing over 400,000 documents--each indexed under fifteen to twenty-five terms--arriving at a listing of relevant report numbers for each of the twenty-five problems in several minutes total processing time. The same task would require several days if done by manual searching.

Acknowledging the power of the computer, the heart of the system is the technical staff member. He provides the linkage between the industrial user and the base of information. The computer is an efficient and effective method of reaching into the information reservoir and identifying relevant reports. However, the effectiveness of the computer is dependent upon the technical search strategy and problem understanding of the person using it to select information. All results provided to industrial firms go through human hands and technical minds.

A set of basic information systems has been designed to cover three broad but interrelated needs. The Selective Dissemination System (SDS) provides for a regular flow of information to the user through the use of an interest profile. The Retrospective Search System (RSS) provides the mechanism for seeking information on specific problems or areas of immediate, high priority interest on the part of the user. The third transfer mechanism is directed toward communicating to the user information on potential industrial application product and process ideas. The systems have been designed with sufficient flexibility to provide inputs to a broad range of the firm's operations including marketing planning, R & D projects, product and process development, engineering and manufacturing. Appendix A of this report is devoted to a brief description of each transfer mechanism or ARAC service element employed to date.

ARAC INFORMATION RESOURCES

The space related literature which comprises a significant portion of the ARAC information base is published in the form of SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS (STAR) and INTERNATIONAL AEROSPACE ABSTRACTS (IAA). These companion abstract journals are published semimonthly and represent a total of 4000-5000 reports per month in all areas of technology. A computer tape on which all reports of the current issue of STAR and IAA are indexed is sent to ARAC. This tape, when processed at the Indiana University Research Computing Center, allows ARAC to screen a large volume of technical literature in a very short period of time. ARAC has STAR on computer tape from April 1962, to date, and IAA from January 1963, to date. This represents nearly 400,000 reports on tape and is one of ARAC's most valuable resources.

Since ARAC operations began in April of 1963, the Technology Utilization Division of NASA has established several other technology transfer and dissemination centers at various non-profit host institutions throughout the country. As of this writing, there are five other centers similar to ARAC, and Appendix B of this report lists the locations of each of these centers. Originally, all of the NASA dissemination centers operated from the NASA resources described in the preceding paragraph. As the centers evolved, it became evident that the effective transfer of aerospace related technology, which was the primary mission for each of the centers, could be enhanced by utilization of additional information resources. Accordingly, the six NASA centers organized themselves into a resource sharing network. The basic scheme of this network is that each NASA center will develop certain unique capabilities and services and then share these special capabilities with each of the other centers. Under this scheme, a user firm of any of the centers would have access to the capabilities of the entire network. The potential for cost savings and economies of scale is very powerful with this arrangement. In general the type of specialties developed at the various centers has been access to additional information resources, although in some cases special areas of expertise have been cultivated. For example, one of the centers specializes in the collection of earth photography and sensing information. The following paragraphs describe a number of the additional resources available from ARAC (or any of the centers). No particular reference to where these data bases are operated is made since all of these resources are available to any firm working with any of the centers through the network concept.

The two most significant (non-government agency) computerized files available to industrial firms through ARAC are the COMPENDEX file and the CONDENSATES file. COMPENDEX is compiled by Engineering Index, Inc. and covers the majority of the world's engineering literature. The CONDENSATES file is a product of Chemical Abstracts Service in Columbus, Ohio and covers the majority of the world's chemically oriented literature. The network also has access to a textile technology file which is a significant resource for firms whose interests lie in this area. Both of these important files are available to ARAC and are used routinely in providing relevant information to ARAC user firms.

Additional ARAC information sources include the U. S. GOVERNMENT RESEARCH & DEVELOPMENT REPORTS (USGRDR) and NUCLEAR SCIENCE ABSTRACTS (NSA). USGRDR is published by the Department of Commerce and represents technical reports in many disciplines and from various government and university sources. However, the majority of reports cited are from the Department of Defense. ARAC's collection of these reports from 1960, to date numbers 80,000-90,000. NSA covers the international literature on nuclear science and technology and provides the only comprehensive abstracting and indexing of this body of information. Nearly 370,000 reports have appeared in NSA since its inception.

Additional resources are continuously being evaluated by ARAC and the other centers in the network. Presently the addition of a metals technology file and a food technology file are under consideration. These two resources will probably be added in the near future. New and useful technical information files are appearing at an ever-increasing rate. Each of these will be evaluated by the network and incorporated as need demands and resources permit.

Another rich source of information available to the ARAC staff member includes specialized information sources such as the Plastics Technical Evaluation Center, Defense Metals Information Center, Science Information

Exchange, etc. A direct contact with a university faculty member or an engineer or scientist in a government laboratory is another alternative for the ARAC staff member in his efforts to solve a user's problem.

Figure 3.1 illustrates a number of the sources of information and expertise which are available to users of ARAC services.

INFORMATION PROCESSING

The design philosophy behind ARAC services includes four features: (1) computerized retrieval of information from the sources described above (where the file is computerized), (2) an experienced engineer or scientist, acting like a colleague of the company man, operating on the input and output sides of the computer or making the search manually, (3) a set of services that communicate idea-generating information to the company man periodically, and (4) a set of services in which the company man "pulls" specific information out of the system for problem solving and other needs. The most important feature is, of course, the experienced ARAC engineer or scientist acting on behalf of the company man. The "push" services are: (1) Industrial Applications Service (IAS), (2) Marketing Information SErvice (MIS), and (3) Computer Information Service (CIS). The "pull" services are: (1) Retrospective Search Service (RSS) and (2) Selective Dissemination Service (SDS). These services are described in detail in Appendix A of this report. For maximum effectiveness, the two sets of services should be used in conjunction with one another.

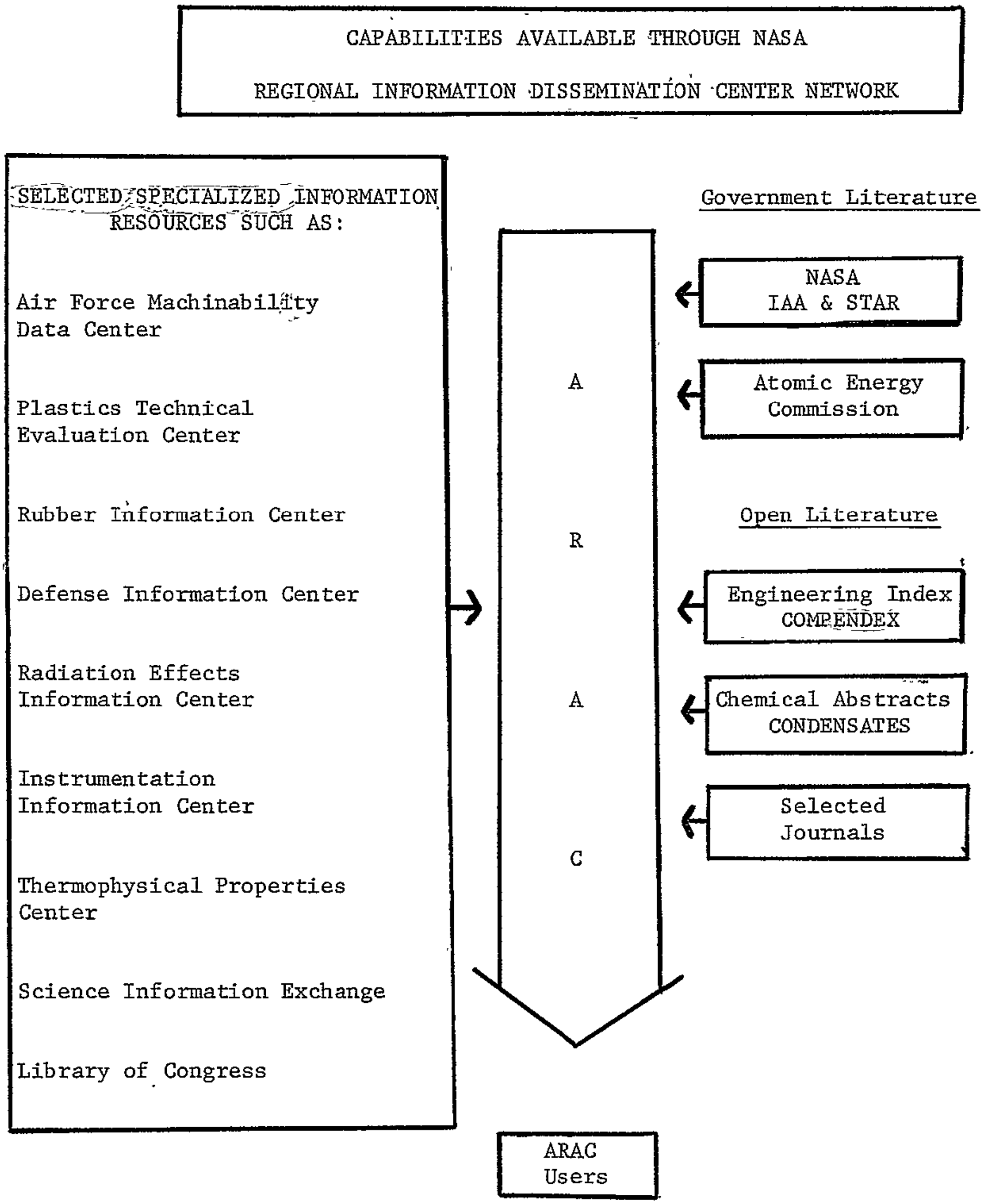
SERVICE OPERATIONS

ARAC provides five services for members on a continuing basis. They are as follows:

1. Retrospective Search Service (RSS)
2. Selective Dissemination Service (SDS)
   - Customized Interest Profiles (CIP)
   - Standard Interest Profiles (SIP)
3. Industrial Applications Service (IAS)
4. Marketing Information Service (MIS)
5. Computer Information Service (CIS)

The ARAC operation is unique in that there is a critical screening process between the vast amount of information available to ARAC on a given subject and the user. A trained, experienced engineer or scientist who understands the user's problems, needs, and capabilities taps the information base via a computer program, or if necessary, by a manual search. After evaluation of the search output, the relevant information is sent to the user. This is not just a series of reports or papers dealing with a given subject, but a set of abstracts which have been critically selected by a highly trained person who has an understanding of the needs and problems of the ultimate recipient of the information. After studying the set of abstracts, the user may obtain more complete information on the subject by ordering the complete report. Or, if it should be desired, a contract may be arranged on a given subject with a university staff member or a government engineer or scientist. The reader is referred to Appendix A for a detailed description of each ARAC service element.

Figure 3.1 Resources Available to ARAC

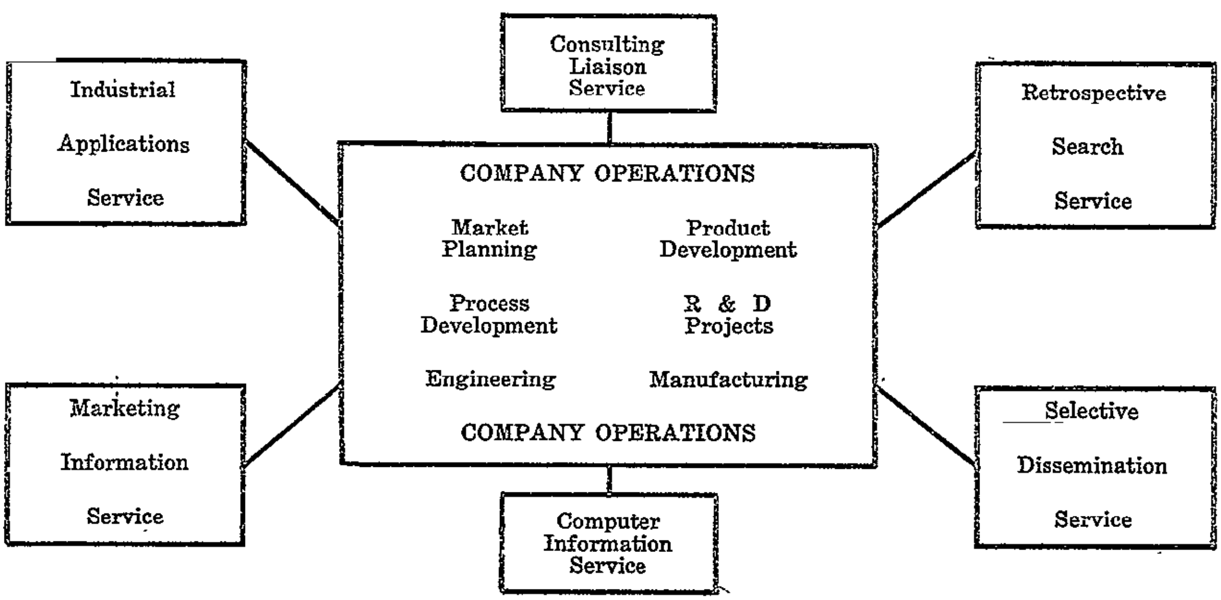


A great part of ARAC's broad capabilities and acceptance may be attributed to the training and background of its staff engineers and scientists. These key members of the ARAC operating team hold engineering or science degrees and have had up to ten years of industrial experience. This background provides an insight into the company's problems.

Continuing telephone contacts, correspondence, and occasional visits between the ARAC staff member and users of the services provide an effective means of maintaining effective communications. The successes ARAC has experienced are because of its sources of information, its staff with varied disciplines and backgrounds, and a large, sophisticated computer installation with a top-flight group of systems analysts.

Figure 3.2 illustrates how the various ARAC service elements provide information for the different segments of a company's operations.

Figure 3.2 ARAC Services and Company Operations



CHAPTER IV: MANAGERIAL COST ACCOUNTING FOR ARAC

In an era characterized by quantitative measurement and cost consciousness, few enterprises operate without the benefits of managerial cost accounting. The complexities, diversities, and uncertainties of the modern age have created a critical demand for relevant managerial cost information. The effectiveness of planning, controlling, and decision making within a given operation often is highly correlated with its cost information retrieval capability. Specific management functions such as cost control, performance reporting, pricing, budgeting, product or service mix selection, make-buy decisions, operating resource forecasting, equipment purchases, performance reporting, and general decision making require a reliable quantitative foundation. Otherwise, efficient selection, procurement, and utilization of the operating resources of an enterprise will be hindered.

Manufacturing firms, retail outlets, military installations, hospitals, governmental agencies, financial institutions, and various kinds of service operations are among the many entities employing relevant managerial cost-accounting information. The investment in and operation of a cost-accounting system is a well-accepted, routine phase of the management process in such enterprises. Without such information, an organization lacks a communication mechanism, a measuring device, an efficiency target, and--perhaps most important--a basis for future operating performance projection.

Until recently, the field of information retrieval has been relatively devoid of systematic cost-accounting applications. Past interest in the area has been concerned primarily with cost estimation and philosophy rather than tangible cost measurement. In particular, technical information centers, which have become increasingly popular in recent years, often have been operated without the benefits of relevant cost information. Very few information centers have had adequate cost-accounting systems and, as a result not much data is available on the cost of information center operations. Despite its apparent importance, there has been very little written in the field of information retrieval which will answer the question, "How much does it cost?" The probable reason for this is that very few information centers have cost-accounting systems; consequently, there is nothing to report.

OPERATING A TECHNICAL INFORMATION CENTER

Fundamental Characteristics

Technical information centers have been established in recent years to cope with the "information explosion" in the scientific community. A product of the intensive research and development effort in the world over the past decade has been an increasing volume and complexity of scientific and technical information available to interested parties. A technical information center employs literature specialists (engineers, scientists, and other technical personnel) to systematically search the diverse information domain. Many centers also utilize electronic data-processing equipment for a high-speed retrieval support function. The man-machine combination provides an effective mechanism for searching the voluminous and complex scientific and technical literature.

A technical information center can be viewed as a manufacturing concern in which the product, information, is developed in various forms during a well-defined production process. The finished product is in turn distributed to the client who originated the request for relevant information in a given area. Consequently, the management function of the operation is highly analogous to that of a typical manufacturing firm, since the enterprise is concerned with the same basic functions of purchasing, production, service, finance, administration, and distribution.

Raw material inputs in the form of various information sources must be selected, referenced, and stored in an effective way. As was mentioned earlier, the production process converts the information sources via the man-machine combination into finished products that are demanded by the center's clientele. The marketing function is necessary to obtain new clients, promote the acceptance of the center's activities, and insure that the operation remains abreast of the current demands of the market. Various supporting functions are required to provide miscellaneous activities such as secretarial, reproduction capacity, heat, power, and maintenance. An administrative segment provides overall direction, policy, and control for the enterprise. The finance function is essential to insure that the enterprise has the capital required to sustain its operation.

One does not have to ponder long to imagine the utter chaos that would exist if the management of a complex manufacturing enterprise suddenly were to find itself without the benefits of reliable managerial cost-accounting information. The effectiveness of the management process and control system obviously would be restricted. Yet, as mentioned earlier, such a deficiency of relevant cost information appears to exist in most technical information centers at the present time.

Cost Information Status

The lack of theoretically-sound cost-accounting applications in technical information centers appears to result from the common procedure of financing library-oriented operations as part of overhead. Libraries traditionally have been financed by indirect sources rather than through charges to the users of their services. Examples are libraries operated by municipalities, the Federal government, universities, service organizations, and business firms. These libraries normally are treated as an indirect service operation of the larger organization, and the operating costs are considered as overhead expenses of the parent enterprise. As a result, little effort has been exerted to calculate itemized service costs associated with specific phases of the operation. Instead, the emphasis has been on the amount budgeted for the various cost classifications such as salaries, equipment, documents, supplies, and travel--based upon, at best, cost estimation procedures.

Although the costs are incurred in order that various information services can be performed, the lack of a sound managerial cost-accounting system has prohibited a reliable association of the costs and related services in most cases. This problem results mainly because conventional information activities normally do not sell their product, hence, are not motivated to be as cost conscious as they might.

Since ARAC is selling its services, this traditional cost treatment proved to be inadequate. Relevant cost information is essential for the proper matching of expenses and revenue. Also, even in information retrieval operations that are not self-supporting from clientele revenue, reliable cost information will be beneficial. Rising operating costs combined with an increasing competition for financial resources have created a critical need for accurate measurement and control of the cost structure. A substantial amount of interest in feasible cost-accounting applications in information retrieval operations has been generated in recent years, but very little tangible research has been directed toward the problem.

ARAC Solution to Cost-Accounting

The remainder of this chapter is concerned with a research project conducted to determine whether or not realistic managerial cost-accounting procedures could be developed expressly for a technical information center. The hypothesis tested in the study was: A theoretically-sound managerial cost-accounting system can be designed to meet the specific characteristics of a technical information center by revising and innovating cost systems utilized by other enterprises.

ARAC's objective at the time of the study was to be completely self-supporting through the fees charged its clientele. In order to achieve this goal, the Center's management realized that accurate service-cost information was essential. Therefore, the main impetus for the cost study was the determination of a realistic cost basis for a revised service fee schedule. During the initial stages of the project, a managerial cost-accounting system was developed for the ARAC operation on the basis of the following elements: (1) generally accepted accounting theory; (2) a review of the relevant literature from such disciplines as accounting, library science, management, data processing, and information retrieval; and (3) information collected on a research questionnaire that was distributed to the management of several technical information centers.

MANAGERIAL COST ACCOUNTING

Essential Features of the System

The components of a managerial cost-accounting system--ranging from source documents such as labor time records, work orders, and computer printouts to reports such as income statements, labor performance reports, and service cost reports--were designed specifically for the Center's operation. The work flows, operating personnel, service mix, cost information requirements and applications, nature and categories of the cost structure, and the record-keeping capability of the Center were analyzed carefully in the design of the system. The Indiana University Research Computing Center system was used for the data processing requirements, and the necessary computer programs were developed to provide the appropriate operating instructions.

A combination of job order and process costing techniques provided the underlying cost-accounting foundation with a specific selection between the two being dependent upon the nature of the service. Job order costing was employed for a given service when its units were distinguishable during the production process. For example, the Retrospective Search Service, which provides an exhaustive historical search for information related to a well-defined problem, contained heterogeneous elements such that each unit could be costed separately. Consequently, the cost items incurred during the production process were recorded and charged to the specific retrospective searches involved. The result of this costing procedure was a job order cost sheet for each retrospective search, which contained a summary of all costs charged to the unit.

The job order technique was not feasible, however, for an activity such as ARAC's current-awareness service (called the Selective Dissemination Service), which provides periodic literature searches for a predetermined clientele interest profile. These profile searches often encompass relatively homogeneous subjects, and thus more than one interest area may be serviced at once. As a result, one cannot always distinguish realistically between service units. Also, an individual search process for a given interest area may require such a diminutive amount of resource inputs that overly-burdensome reporting procedures would be required to record specific unit charges. Therefore, a process costing method was employed in such cases so that all costs incurred for a given performance of the total current-awareness service were collected for a period and later averaged over the unit searches. The result was a set of mean unit search costs based upon a weight-average distribution of the total service costs with the appropriate weights being calculated by the relative number of documents identified for the specific units.

The fundamental features of the system are outlined in Figure 4.1.

Responsibility Accounting

Responsibility accounting and service costing were accomplished simultaneously with the computerized cost system. Responsibility accounting provides a mechanism with which the controllable costs of a technical information center not only are charged to the related information service but also are traced to the person accountable for the performance of the work activity. ARAC's organizational structure was divided into a group of responsibility units (cost centers) to accomplish this objective. Four cost centers, shown in Figure 4.2, were established for the major production functions of the center--engineering, clerical, service, and computer.

The employee responsible for a given section's work performance also was held accountable for the controllable costs consumed during a monthly period. A fifth cost center encompassed the entire process and was the responsibility of the manager of operations. His cost center included the controllable cost performance of the subordinate responsibility units as well as that of his own work activity. The coding classifications of

Figure 4.1

Basic Components of ARAC Managerial Cost Accounting System

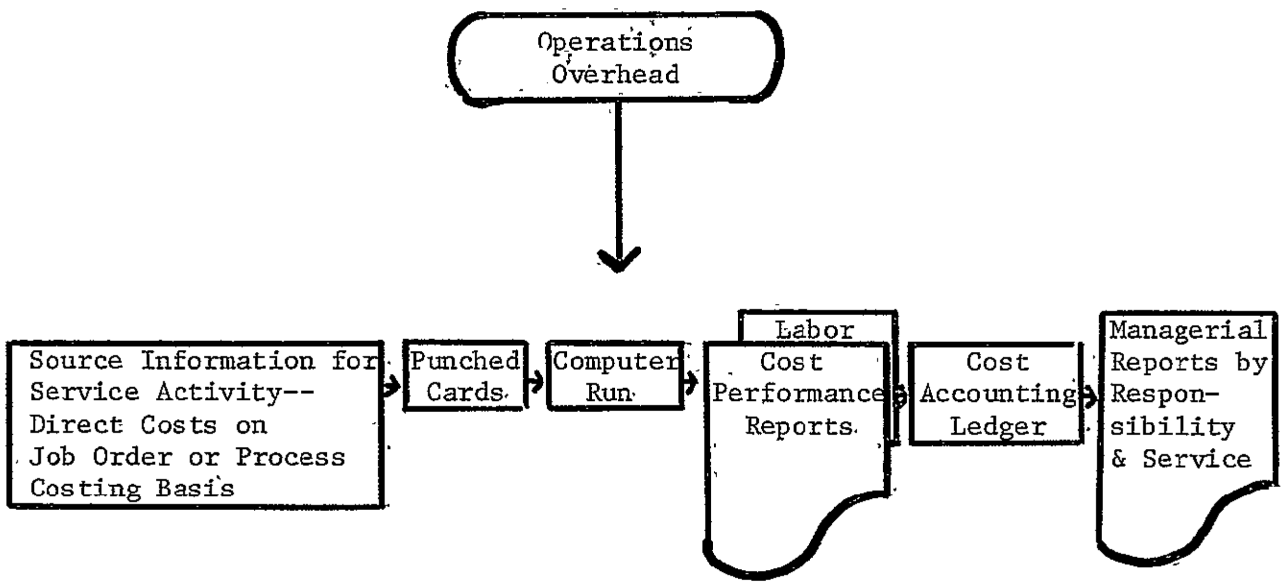
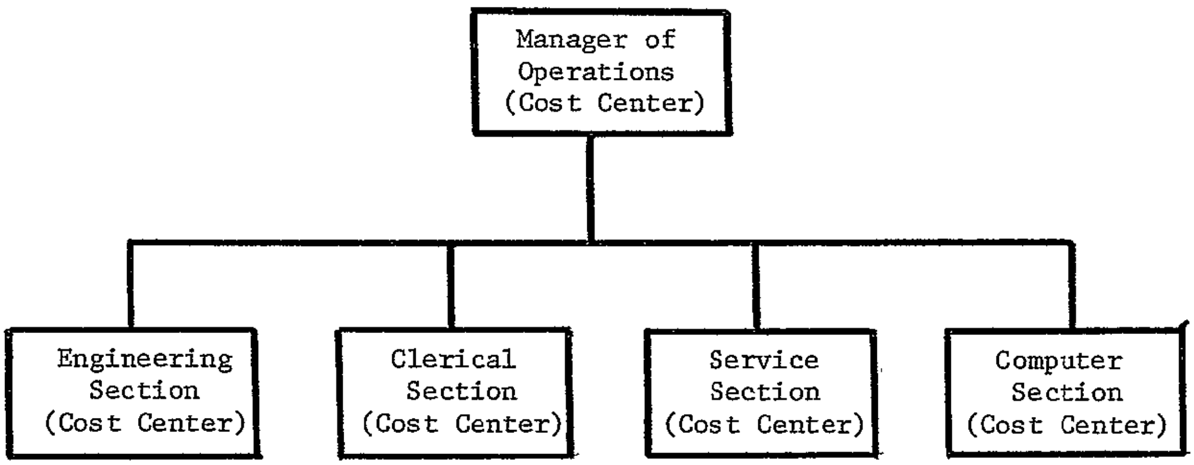


Figure 4.2 Responsibility Accounting Framework



the cost system were designed in such a way that cost information recorded and reported could be identified with the specific cost centers. A computerized cost-reporting system generated weekly and monthly performance reports on the basis of the responsibility accounting classifications. The reports provided a complete accounting of the nature and magnitude of specific expenses incurred for the activities of the center.

Cost Elements and Distribution

The direct costs consumed during the information production process were recorded on various source documents as the work activities were performed. Due to the specialized nature of the ARAC operation, the two primary costs are labor and computer time. Labor is a particularly costly item due to the education and training required for the information searching function. Consequently, an accurate accounting of the labor costs was essential for a realistic cost system. Yet, due to the type of personnel involved, this objective had to be accomplished without presenting them with an overly-burdensome task. A daily labor time ticket was selected for the reporting function as a compromise between excessive detail and relevant data and was utilized by all employees concerned with the production process.

A set of cost codes was standardized for the work activities so that each employee merely identified the services he performed during the day as well as the related time periods. The form provided a complete description of the employees' work performance and furnished sufficient detail for the computerized data processing function to print an exhaustive classification of the labor performance of each cost center.

Computer time was recorded by the machine itself as the information searches were performed. A specialized program was developed to classify the computer time according to the related service. The total computer time also was categorized into the segment necessary for direct searching and that required to maintain the system or update the information file. The assignment to one of the two classifications determined whether the computer time was considered a direct cost or allocated indirectly to the services.

Other miscellaneous cost items that were treated as direct costs whenever appropriate were telephone calls, travel, and operating supplies. These costs were recorded as they were incurred on a telephone log, a travel voucher, and a work order, respectively. Once again, a coding system was used to classify the costs by service and responsibility.

Operations overhead contained those indirect charges that were incurred on behalf of the production process but could not be traced realistically to specific services. Supervision, fringe benefits, depreciation, rent, indirect labor, idle time, staff meetings, and postage are items that were charged to this category. These costs were distributed to the services on the basis of a predetermined rate, which was calculated from the expected production capacity of a flexible overhead budget. The flexible budget was developed for an annual period to adjust for the fact that a portion of the total indirect expenses are variable since they change in proportion to the work activity. Service activity was forecast on the basis of expected consumer demand for the information services, and the corresponding budget level was utilized for the selection of the predetermined overhead application rate. In the ARAC study, direct labor costs were used as a measure of work activity, and for every dollar of direct labor costs charged to a given service, the predetermined amount of operations overhead also was assigned.

Electronic Data Processing

The source information recorded during the production operation was keypunched for computer processing with a coding system prescribed in the computer program. The labor data were keypunched at the end of each week, and a computer run generated a printout which classified the individual work increments performed by each employee in the various cost centers. The goal was to have the weekly labor performance report available to the responsible managers on the Monday following a given week. Such an up-to-date statement provided not only valuable insights into historical activity, but also furnished a realistic basis for future work scheduling. The summary section of the report also presented useful planning and control information for management since it showed the total labor hours, by employee classification, consumed for each job activity. An abbreviated example of the weekly labor performance printout is shown in Table 4.1 with the various terms denoting specific cost codes of the ARAC system.

At the end of each month, the same keypunching operations were performed for the other direct costs (computer time, telephone calls, travel, and supplies). Unit cost rates for the direct items were recorded on punched cards so that a monthly computer run converted the physical quantities to monetary values. Also, the predetermined operations overhead rate was entered into the computer so the machine allocated overhead at the same time the direct labor costs were calculated. Consequently, the monthly report represented a complete description of the cost performance required for the period's work activity. Both responsibility accounting and service costing were accomplished simultaneously on this report due to the classification system employed. A percentage breakdown of the cost elements required for each service also provided valuable information for the planning and control functions. An abbreviated example of the monthly cost performance report is illustrated in Table 4.2.

Cost Accounting Ledger

A manual cost-accounting ledger provided the permanent files for the cost data. The volume of the required accounting transactions was analyzed and determined to be insufficient to warrant a computerized capability. Also, due to the nature of the cost data presented on the cost performance printout, a minimum amount of labor was necessary to transfer the information to the ledger accounts.

A well-defined chart of accounts was developed to satisfy the operating conditions of the center and to coincide with the coding system used for the electronic data processing function. The chart of accounts also was oriented toward the performance of responsibility accounting and service costing. The resulting ledger represented a summary record of every account established in the chart of accounts. As current transactions occurred during the center's operation, the ledger files were updated accordingly.

Table 4.1 Weekly Labor Performance Report

Section	Man	Data	Job Activity	Hours
Engineer	101	67-07-05	RS 3270	2.00
	101	67-07-05	RS 3420	2.00
	101	67-07-05	RS 3399	4.00
	101	67-07-06	RS 3645	8.00
	101	67-07-07	RS 3700	8.00
	101	67-07-08	RS 3724	8.00
	101	67-07-09	RS 3726	8.00
	Service Category		Totals-Engineering	
	OP		206.50	
	SD		413.50	
	RS		130.00	
	SS		140.25	
	Total		890.25	

Table 4.2 Monthly Cost Performance Report

Job	Section	Man	Hours	Base Cost	Operations Over-head	Total Cost	Per-cent of Job
RS3342	Engineer	103	8.00	40.00	40.00	80.00	92.8
	Clerical	204	.50	.85	.85	1.70	5.0
	Service	3.5	.75	2.59	2.59	5.18	2.1
	Job totals		9.25	43.44	43.44	86.88	100.0

The monthly cost performance report provided the vehicle for most of the recording process as the data were transferred from the printout to the appropriate accounts. The coding system was designed to facilitate this operation since the data could be transposed in the same form without additional computations.

Consequently, the ledger provided a perpetual record of the cost-accounting history of the center as well as the source of the information required for numerous forms of managerial reporting. Included in the reporting process were such items as financial statements, cost center performance reports, service cost reports, revenue-cost comparison reports, and overhead analysis reports.

RESULTS OF THE ARAC COST STUDY

Analysis of Cost and Operational Data

The results of the ARAC study indicate that theoretically sound managerial accounting techniques definitely are applicable in a technical information center. The proposed cost system was operated effectively for a three-month test period and generated relevant cost data for the management process. The electronic data processing function performed the major portion of the record-keeping phase of the system, requiring only thirteen minutes of computer time. A part-time clerk supplemented the data processing phase, and the total expenses associated with the maintenance of the system amounted to approximately $244, or $81.33 per month.

In this section, several general cost and operational statistics are presented as a summary of the ARAC cost results. A wide variety of data could be disclosed; however, the author's intent is to select those statistics which were considered essential by the ARAC management, but at the same time are not unduly restricted to that operation's unique characteristics. Most of the data were reported to the responsible managers on a monthly basis.

Table 4.3 shows the average monthly unit cost for the center's two major services, retrospective search and selective dissemination (profile search). As of the first quarter of 1967, the units costs were very consistent between monthly periods as the average retrospective search only varied by 1.9% and the mean profile search cost deviated by 3.2%.

In Table 4.4, the unit retrospective search cost is divided into the individual expense categories that were recorded during the production process. Direct labor (engineer, clerical, service, and computer), computer time, and operations overhead constitute the major cost items, averaging 39.2%, 31.4%, and 22.6%, respectively. The same measurement is presented for the Selective Dissemination Service in Table 4.5. Once again, the heavy commitment for the same three categories is shown by the fact that they constitute 96.8% of the total costs.

Effective planning and control of the labor costs are essential in a technical information center because of the magnitude and major role of this element. Table 4.6 shows the breakdown of the total direct labor hours as measured with the ARAC cost system. Since engineering labor represents the primary element of a center's capacity, its effective utilization is essential for a successful operation. Table 4.7 shows the average amount of engineer labor recorded for the two types of information searches, while Table 4.8 exhibits the distribution of the total engineering effort into the various services performed by the center.

The final two illustrations are concerned with ARAC's operating cost structure, both from an expense classification perspective and that of the distribution of the service costs (direct and indirect) to the center's work activities. Table 4.9 shows a percentage breakdown for the amounts recorded in the major expense classifications employed in the ARAC chart of accounts. Once again, the heavy commitment for labor costs is disclosed, as they constitute over 65% of the total operating costs. The final table (Table 4.10) represents a percentage distribution of the cost effort recorded for the individual services. The only costs that are not included in these figures are the selling and administrative expenses, which are period rather than service charges.

Managerial Applications

While it is too early to accurately assess the total impact of the cost system on the management process, a few observations are apparent on the basis of initial uses of the cost data. A major objective was accomplished when a revised fee schedule was initiated based upon the unit costs generated by the system rather than the previously-used estimates. Monthly financial statements were made available to management for an analysis of the status of the operating performance and financial condition. Planning for future manpower, equipment, capital, and other resources via sounder budgeting procedures than those employed prior to the use of the system was achieved. Scheduling workloads and analyzing the operating performance also was based upon objective quantitative measurement.

The substantive fixed-cost element of the center's operation also was disclosed by the cost system. Approximately 70% of the total costs incurred were classifiable as fixed expenses. The high salaries required to attract and retain the skilled personnel necessary for the center's operation were the major factors contributing to this phenomenon. Due to their specialized training, these employees are not the type that can be hired and discharged or laid off frequently. Consequently, the Center cannot vary their salaries in proportion to service volume unless sufficiently long lead times prevail. Such expenses can be categorized as programmed fixed costs, which means that the amount can be adjusted only during the planning stage of the operation. Once again, this characteristic illustrates the critical need for a reliable quantitative measurement with which future manpower requirements can be correlated with the expected service demand.

Table 4.3 Average Monthly Service Cost

Service	First Month	Second Month	Third Month
Retrospective Search	$85.17	$86.13	$86.87
Profile Search	7.46	7.22	7.28

Table 4.4 Cost Distribution of Average Retrospective Search

Cost Item	Amount	Percent
Direct Labor	$33.64	39.2
Phone	4.05	4.7
Supplies & Document Reproduction	1.83	2.1
Computer Time	27.11	31.4
Operations Overhead	19.43	22.6
Total	$86.06	100.0

Table 4.5 Cost Distribution of Average Profile Search

Cost Item	Amount	Percent
Direct Labor	$3.22	44.0
Supplies & Document Reproduction	.24	3.2
Computer Time	1.38	18.8
Operations Overhead	2.48	34.0
Total	$7.32	100.0

Table 4.6 Breakdown of Total Direct Labor Hours

Labor Element	Percent
Engineer	37.6
Clerical	18.5
Service	37.7
Computer	6.2
Total	100.0

Table 4.7 Average Engineer Time Per Search

Service	Average Engineer Time
Retrospective Search	4.63 hours
Profile Search	.61 hours

Table 4.8 Engineer Time by Service Element

Service	Percent
Retrospective Search Service	23.8
Selective Dissemination Service	49.5
Industrial Applications Service	4.5
Marketing Information Service	9.2
Computer Information Service	2.3
Special Projects	10.7
Total	100.0

Table 4.9 ARAC Operating Cost Structure by Accounting Classification

Classification	Percent
Service Expenses	
Engineer Labor	25.8
Service Labor	6.5
Clerical Labor	3.9
Computer Labor	2.4
Supplies and Document Reproduction	7.4
Telephone	1.6
Computer Time	6.0
Postage	2.3
Travel	2.3
Depreciation	2.0
Miscellaneous	2.3
Subtotal	62.5
Administrative Expenses	
Administrative Labor	26.7
Supplies	.6
Telephone	1.0
Travel	.8
Depreciation	.4
Miscellaneous	3.4
Subtotal	32.9
Selling Expenses	
Promotion	3.8
Advertising	.5
Travel	.3
Subtotal	4.6
Total	100.0

Table 4.10 ARAC Service Cost Distribution

Classification	Percent
Retrospective Search Service	16.8
Selective Dissemination Service	28.0
Industrial Applications Service	9.7
Marketing Information Service	4.0
Document Service	4.1
Computer Information Service	2.8
Special Projects	34.6
Total	100.0

CHAPTER V: MARKET ACCEPTANCE AND USER INTERFACE PHENOMENA

Nearly seven years of experience suggests that a large number of problems and barriers to the transfer of technology are people problems rather than limited applicability of government or other information files to industrial situations. The breadth and depth of NASA's technology, for example, are extensive, recognizing that seldom is there a one-to-one correspondence between a particular industrial problem and the information base. A company cannot expect to reach into the R & D catalog of resources and pull out complete product and process ideas. Rather, the task is one of matching elements and portions of knowledge to a company's problem solving and idea generation efforts. Most important, obtaining relevant information does not complete the task. The firm must provide technical capabilities to integrate and transform information inputs into results. ARAC and other similar information intermediaries that have both a knowledgeable technical staff and a computerized information retrieval capability are uniquely equipped to supply the firm with carefully selected technology "building blocks." Integration of these knowledge chunks into a total solution rests with the firms.

Realization on the part of prospective user firms that a commitment on their part is required for effective utilization of ARAC-like services is the first step in building a lasting and fruitful relationship. Expectations on the part of prospective user firms must not be inflated. The receipt of relevant and timely information services is significant only so long as a willingness to put the services to good use exists in the firm. This chapter discusses some of the ARAC experiences in selling potential user firms on the technology transfer concept and in maintaining meaningful relationships through extended years of service.

INFORMATION DISSEMINATION ON A FEE PAYING BASIS

Emphasis on marketing is simply a product of the times. During the past decade everyone in information center operations has been creating their organization, developing information retrieval tools and techniques, and attempting to create an integrated, well-oiled operation. Those information centers which have been in operation for some years now and as yet do not have refined operations may be destined not to survive. It is probably safe to assume that those mature organizations which have solid operations at the present time are technically competent and sufficiently well staffed to provide some form of dependable information services. There is evidence that subsidies for information center activities which were prevalent during the past decade are now in the process of diminishing. The future existence of viable information centers will depend on their ability to obtain remuneration for their services. The marketing point of view will probably be a major theme for information centers during the coming years.

It would appear that information centers and their various activities, having been around for several years, should be familiar to anyone working in a research and development effort. This is not the case. Recent experiences of ARAC reveal that there still remains a great ignorance with regard to the availability and orderly procurement of information.

The engineer or scientist working in a research and development function usually is not accustomed to utilizing outside information. He may occasionally browse several technical journals, but he has neither the time nor inclination to maintain a comprehensive information awareness about his area of specialty. In addition to the information explosion of the past few years, so much has been going on in the development of information resources that the average engineer is, to a large extent, uninformed as to what is available, thus serving to compound his problem.

With this situation prevalent there is a clear cut necessity for information centers to maintain a constant program to inform the potential user public as to what is available and how to obtain it with a minimum of difficulty. Without such an approach it will be impossible for information centers to reach the degree of effectiveness and scale of operation which they must in order to develop into self-sustaining operations. While the problem of user awareness is quite critical to information centers, the problem of closing a sale is probably paramount at the present time. In the case of information centers, selling the basic products produces unique difficulties. These difficulties arise because benefits derived from information are largely intangible and present difficulty in attempting to assign a dollar value. As a consequence it is sometimes difficult for a firm to defend expenditures for information services.

ARAC experience over the past seven years indicates that there is yet another very distinct characteristic connected with the sale of information services. Information services are not simply sold to a single person or single group within a firm. It appears that in order to finalize a sale of information services it is necessary to sell the services to three distinct groups. The initial contact can occur through any one of these three groups with a potentially successful conclusion. Because an organization's management will ultimately make the yes or no decision with regard to the expenditure of corporate funds, it is usually desirable to make the initial contacts and presentations to some level of management such as the R & D Director. In selling to this level of management the following situaiton usually prevails. The manager should be aware of the value of good information services. The manager will point out that his organization already has some form of technical information section or division which may vary from a few technical journals in a small room to a corporate-wide information system.

At this point the seller of information services must ascertain the in-house capabilities of the firm. There exists a broad spectrum of information services and there is always a good chance that the services available from the Center will, in some manner, complement those services which are already being provided by the corporate information function. The approach must be taken that externally purchased information services will serve to strengthen the in-house effort at reduced costs. It must be remembered that the corporation probably has a significant investment in its information function. No matter how capable and inexpensive an information center may be, it is not going to replace in its entirety the already existent corporate information function. Emphasis must be made toward the economy which the manager can achieve by using the center's services in a complementary fashion as opposed to the development of equivalent in-house capabilities.

Acceptance of the concept with the firm's management should result in the information center representative being introduced to the corporate information function. At this point completely different considerations enter into the problem of closing the sale. The information specialist who typically staffs this function in a firm is a technician in every sense of the word. He will carefully assess and scrutinize in a detailed fashion every aspect of the information center. He will require answers to questions which will ascertain the ability of the information center to deliver its product on a dependable basis. The information center representative must convince the corporate information function manager that the purchase of the center's services will serve to strengthen his position and importance to the firm rather than dilute it. The information center representative must suggest a package of services for the corporation and probably lay out many of the details of mutual co-operation which will be necessary in order to achieve an operating agreement.

After the sale is closed at this level, the center representative may have to make a totally different presentation to the engineers, scientists, and other technicians who will be the ultimate users of the center's services. This situation does not always previal, but from the point of view of the information center this is the most desirable procedure to follow. The interaction with the ultimate user of the information is very useful in specifying a service package that will meet the needs of the user and will thereby contribe toward a continuing business arrangement with the corporation. In many instances the corporat information department will act as an intermediary between the ultimate user of a center's information services and the information center. This approach has proven to be quite workable in many instances and serves to focus attention back to the firm's in-house information capabilities. In such cases the success of the overall arrangement will depend upon the goodwill and professional dedication of the information specialist who is co-ordinating the center's information services with the user in the corporation.

If the information center representative does deal directly with the ultimate user of the information, he will have to make a technical presentation which will require an in-depth understanding of the nature and quality of the information contained in the data bases on which his information services are found. This type of contact with the information data bases almost precludes presentations by anyone other than the center's technical staff who deal with the information resources of the center on a day-to-day basis. In many industries, a similar problem is circumvented by having the technical staff contribute to the development of sales brochures and presentation materials of sufficient quality to permit a professional salesman or administrative staff member to transmit all the essential information about the product being sold to the potential user. There seems to be no completely successful program of this nature in use in the information business today. This situation may be explained, in part, by the nature of the product.

USER INTERACTION: KEEPING THE SALE MADE

If one looks at the user interface problem from the point of view of the management of the information center, it is apparent that one has little guidance as to what types of information services to offer. At the present time there exists many well organized and controlled data bases. The number of technical information files seems to increase almost monthly. Economic considerations preclude attempting to offer every data base which becomes available. However, for resources expended the information center will want to provide the broadest possible spectrum of data bases which can effectively be integrated into the center's operation. An information center's ability to evaluate effectively and integrate new data bases into its operation is certainly a significant factor in maintaining satisfied users. A successful relationship between a user firm and the information center can be maintained only so long as the center remains a trusted source of information to the firm. Implicit for this condition to obtain is the periodic evaluation of new information resources with appropriate incorporation of the new resources when justified.

The paramount requirement in keeping the information services sale made is for systematic feedback and liaison with the user firm. Three distinct groups in firms have been identified above as having involvement in selling information services. Each of these three groups require a different marketing approach. Once again, in the area of continuing user interaction three separate efforts must be maintained although certain overlapping aspects exist.

The management group in a firm must be kept aware constantly of the impact on the firm as a result of its association with the information center. This may be accomplished in a variety of ways. A light but continual flow of highly refined information concerning the firm's association with the center must be maintained with the management group. This group, however, is extremely sensitive to bulk and must not be overwhelmed with paper. An image of dynamic efficiency with genuine concern for the quality of the relationship must be conveyed. An important part of the flow of information to the firm's decision maker with regard to purchase of information services must come from the users within the firm. The information center must play an aggressive role in the implementation of a feedback system internal to the firm. A number of other techniques are available to maintain visibility with the decision maker. One approach which ARAC has taken is to devise several cyclic-type information services aimed at executives. Specifically, these are the ARAC Management Science Service and Marketing Information Service.

Liaison and interaction with the corporation's information function is perhaps the most strategic level of coordination for the information center. The ultimate users of the service and the firm's management normally do not have the inclination to spend excessive time for coordination.

However, this is the primary responsibility for the firm's internal technical information system. He should be consulted prior to any major changes in content of service, prices of services, frequency of occurrence, etc. He should be given assistance in finding new and ingenious uses for the services he has purchased. The most successful relationships occur when the services of the information center can be used to embellish and enhance the value of a service formerly provided in its entirety by the corporate information man. Several additional techniques have been used at ARAC which have served to "lock in" the firm's corporate technical information director. One of these was the establishment of an ARAC industrial advisory board composed primarily of the technical information directors in the various ARAC user firms. This board meets once or twice annually and makes significant contributions to ARAC planning. Another effective technique has been the provision of brief periodic reports to these persons which depict the extent of utilization of the center's services. At ARAC these activity reports are provided bimonthly and are computer printed. These activity reports are also used for billing purposes at convenient time intervals and form an integral part of ARAC's internal management information system. Thus, provision of the bimonthly activity reports may be accomplished with relatively little additional cost.

The most detailed interaction of all is between the users of the information and those people in the center who are actually providing the information services. It is at this interaction level that the success of an information center will be determined to a great extent. This interaction should be handled by frequent telephone contacts and occasional visits between clients and information center personnel. At this level of contact the information center can gain useful intelligence concerning the ever changing needs and interests of a client organization. It will provide access to the pulse of the market which would otherwise be difficult to assess.

Another aspect of the user interface problem is the packaging of the product. Those items of information which represent the output of the information center have several potential effects. The factor which should be foremost in the thoughts of the information center's management is that each product or information item which is sent to a user either contributes to or detracts from the overall image of the information center.

As an example let us assume that the information center sends out a document in hard copy form. If this document is sent out in some format which is not easily readable and if the document is presented on an undesirable type of paper, chances are high that no matter how useful the information in the document may be, the user will not form a favorable opinion of the information center and in all probability will treat the report as an expendable item. What should be sought in this case is a presentable hard copy that carries with it an air of permanence much like a book. This can be achieved, for example, by using inexpensive covers bearing the logo of the information center on all items disseminated (both service elements and reports). This would serve to keep the attention of the user focused back to the information center and would create the impression of a coordinated set of information services and products.

Another aspect of the user interface problem should be given more emphasis than it has to date. It revolves around the problem of integration of the center's services into the normal routine of the user. People tend to be creatures of habit, feeling satisfied with things to which they are accustomed. They develop attachments to those items in their weekly and daily routine in which they are immersed. It becomes of utmost importance that cyclic or repetitive services, such as periodic current awareness, be kept to a strict schedule. The user should be able to expect the output of these services to arrive with high predictability. As a corollary to this point, it should be obvious that an information center must offer services, such as current awareness, which are repetitive or cyclic in nature.

USER ACCEPTANCE OF ARAC SERVICES

There are a number of quantitative indicators that can be used in an attempt to assess the success of a university-based center. These indicators include such factors as number of profiles on line, number of retrospective searches performed in a quarter, number of document requests, etc. In attempting to measure the success of a university center at meeting the market test, the task is not quite so obvious. The reason is that some of the operations of the center involve research on the transfer process and service to the host institution. Costs associated with these functions are difficult to separate from costs incurred as a direct result of providing service to user firms. Information on hand to date indicates that it is possible to obtain the sufficient volume necessary to operate a center on a break-even basis form revenues generated.

One of the more quantitative ways of measuring success at meeting the market test is to look at the renewal records for ARAC user firms. Table 5.1 shows a condensed version of ARAC client histories for member company firms only. Two significant observations may be made. The renewal rate for member companies is excellent in terms of the percentage of firms that renew. Secondly, the best progress in terms of number of member clients added per year has been made during the latter three years.

In examining Table 5.1, it can be seen that a total of 144 firms have been ARAC member companies. Of these, 115 are still members for an overall renewal rate of 80% in the seven year history of ARAC. It is significant to note also that 23 of the original 29 charter member firms are still ARAC member companies. The size of these recurring annual memberships, in terms of dollar amount, fluctuates on a year to year basis depending primarily on the firm's R & D activities. But it appears that a lasting relationship is being established with most ARAC member companies indicating that attitudes and habits toward receiving information in an organized manner are being changed.

Several years ago a survey was made of the first fourteen firms that terminated their membership relationship with ARAC. Table 5.2 gives a brief description of the reason given by each firm for terminating its relationship with ARAC. The brief statements are self-explanatory to a large degree. Note, however, that a significant number of the reasons given are "people problems" rather than any basic flaw in the concept.

Table 5.1

SUMMARY OF ARAC COMPANY MEMBERSHIPS

	1963	1964	1965	1966	1967	1968	1969	1970*
Member Companies at Beginning of Year	0	29	33	44	48	67	73	109
New Members Added	29	7	13	11	22	16	38	8
Memberships Terminated	0	3	2	7	3	10	2	2
Member Companies at Year End	29	33	44	48	67	73	109	115
Net Gain in Member Companies	29	4	11	4	19	6	36	6
Percent of Companies Renewed	N/A	90%	94%	68%	94%	85%	97%	Incomplete Data

*First Three Months Only

Table 5.2

BRIEF SUMMARIES OF REASONS GIVEN BY FOURTEEN FIRMS FOR TERMINATING MEMBERSHIP WITH ARAC

1. Insufficient engineer hours internal to the company to utilize ARAC output. Company very satisfied with ARAC services.

2. Corporate reorganization and establishment of a company "library" rather than technical information services.

3. This company maintained that taxes had already paid for the information and that they should not have to pay again. Stated otherwise, they either refused to recognize or could not recognize that the payment of fees was for the value added to the information by ARAC.

4. Upon death of the owner, this company was dissolved according to his last will and testament.

5. This company gained access to essentially the same data bases as ARAC through government contracts in their Aerospace Division.

6. This company was bought out by another firm. The new owners did not replace the company information services function.

7. The person who coordinated the ARAC membership at this firm was retired from the firm and used by the firm on a quasi-consulting basis. The coordinator was very far removed, both in interest and distance, from the actual users of the ARAC services. He decided not to continue the membership even though in several instances he had been informed via carbon copies of letters from users that the services had been of some value. An additional factor was involved because the primary users were in a subsidiary firm while the budget for information services was controlled at corporate headquarters.

8. Profits in this firm were down, there was a severe cutback in engineering staff, and the firm was exercising all possible economy measures.

9. Technological mis-match for this firm. The research center of the firm may renew later.

10. The coordinator and management at this firm refused to exploit and/or apply ARAC services. The interests of this firm are in areas where great potential for assistance by ARAC services exist.

11. No engineering talent in the firm. Technological mis-match.

12. This firm liked the type of services provided but wanted access to a more chemically oriented data base.

13. This firm felt that they might obtain similar services through their State Technical Services Agency at no cost.

14. This firm developed their own internal system with access to NASA tapes. Ironically, ARAC supplied the computer retrieval programs.

The upswing in new memberships added during the latter three years (see Table 5.1) may be traced almost entirely to revision of the ARAC fee schedule, the adoption of low-cost standardized services, and to the increased coverage of information files provided through ARAC services. Prior to 1967, ARAC operated with a blanket-type of fee schedule which effectively served to put the cost of ARAC services out of reach for small and medium sized firms. After the ARAC management cost system was implemented, it was possible to calculate a realistic internal ARAC cost associated with each service element (see Chapter IV). Eventually, a unit cost fee schedule was adopted where each service element was priced separately. The total annual fee paid by a firm was entirely sensitive to the size of the service package required by the firm. The unitized fee schedule served to make ARAC membership equally as attractive to small firms as it was to the industrial giants.

In 1967, the first moves were made twoard expanding the ARAC information resources with the addition of the AEC and DOD technical information files to ARAC information products. In 1969, the CITE files from Engineering Index, Inc. were added and use of the Chemical Abstracts CONDENSATES file was negotiated. Addition of these resources played a significant role in the ability of ARAC to attract new clients since it tended to make prospective clients view ARAC as a one-stop information supermarket. The slight letdown in obtaining new clients during 1968, is traceable to a budget problem at ARAC in late 1967, and early 1968. The addition of these new data bases was viewed by NASA as an enhancement of the ability of ARAC and the RDC network to do effective problem solving, thus increasing the potential (through generation of added interest and a broader client base) for the transfer of aerospace technology.

In may be useful to examine what has been learned to date about operating an information center on a break-even basis for costs involved in providing service to fee paying firms. Important findings to date indicate: (1) expectations toward this objective may have been overly optimistic originally in terms of time required, (2) interest, on the part of industrial managers, in this relatively new concept has been very high, but involves delay because it represents departure from traditional methods of seeking new information/technology, (3) operating with a limited information resource severely hampers a center's ability to appeal to a diversity of information needs in potential user firms, (4) personalized services ideally suited to small business (see next section of this chapter) usually do not generate break-even revenues, (5) even a variety of promotional activities from a regional center does not effectively communicate the transfer concept, and (6) information seeking habits of R & D people which were instilled as a part of their formal education are difficult to change and that in-depth penetration and acceptance of the concept will come only when the first generation of researchers and managers formally educated about the transfer concept take up responsible postitions in firms.

SERVING SMALL BUSINESSES

One of the most significant observations made as a result of the ARAC experiment is that special considerations must be made in attempting to fill the new technology/information needs of small businesses. The one critical dilemma may be summarized as follows. From the viewpoint of an information center, small firms are more costly to work with because greater engineering time is needed in definition of a problem, more search time is consumed in finding a specific solution because of economic constraints in applying the solution, and more time is consumed in explaining and applying the solution with the small business technical staffs. At the same time the managements in smaller firms are comparatively less likely to recognize the potential significance of receiving relevant information in an organized manner. The major observations presented in dealing with small business are primarily a result of one specific study done at ARAC. A brief description of this study follows.

Description of the Experiment

Late in 1965, officials of the National Aeronautics and Space Administration (NASA) and the Small Business Administration (SBA) launched a joint effort aimed at developing more effective techniques and methods by which the small business industrial and R & D communities might obtain the benefits of government generated technological and scientific information in order to strengthen their competitive position in a rapidly changing economy.

The Aerospace Research Applications Center (ARAC), along with certain other of the NASA Regional Dissemination Centers (RDC), was asked to participate in the experiment. The ARAC role has involved four phases:

1. Orientation and training of SBA representatives in technology transfer concepts and mechanisms to enable them to more effectively select company participants in the program.

2. Establishment of an operating arrangement with each of the participating industrial firms via a one-day planning meeting held individually with each firm.

3. Implementation of transfer mechanisms designed to meet the particular needs and interests of each business firm; continuation of the operating relationship for twelve months.

4. Evaluation of operating experience, results achieved, problem areas, and future potential for technology transfer in the small business sector.

The basic content of this summary is drawn from the experience ARAC has gained in working with the seven firms in the experiment. However, it is appropriate to point out that the Center has a number of regular fee paying customers that are members of the small business sector. Accordingly, this experience has also influenced the contents of the summary.

Each of the seven firms included in the pilot project was carefully selected by SBA representatives in the Indianapolis and Chicago areas utilizing the following criteria:

1. Technical depth within the company.
2. The "fit" of their requirements with the available NASA technology.
3. Willingness to adapt and innovate.
4. Reliance upon technological input for success.
5. Present good competitive position as opposed to present distress.
6. Non-competitive with other selectees.
7. Real and definable technological objectives or problems rather than exploratory, with real opportunities for utilization of resulting information.

These criteria seem to have been met reasonably well, recognizing that it would be unusual to find all characteristics in a given firm, and that certain of the criteria are, at best, difficult to evaluate for a given firm. The lack of background necessary to evaluate technical capabilities on the part of the SBA representatives may have led to poor selection of at least one of the firms.

A number of potentially significant technology transfers were made during the experimental program. One contributed to the development of a new product with projected three year sales of approximately $1,000,000. This transfer alone may substantiate the need for further information transfer experimentation in the small business sector. Transfer efforts for another firm have apparently made major contributions toward the development of an artificial heart. This company is also planning to request a license from NASA to manufacture a magneto-fluid announced via a NASA TECH BRIEF.

In commenting upon ARAC's information transfer capabilities the president of one of the firms indicated:

> It should be pointed out that this service is not a panacea for the small company. But, it can provide 'bits and pieces' of information which can be used in the development of new ideas. In short, this service, if used properly, can enable a technologically based company to obviate some engineering effort by insuring that the particular design problem has not been solved before.

Several other useful results from the experimental program have provided insights into the process of technology transfer in the small business sector. Among these is the nature of the interface between the firm's technical capabilities and externally generated technology. A continual interaction between the external technology transfer agent and the technical group in the firm appears vital in accomplishing effective transfer of information. The depth of effort must be sufficient to link the company with usable technology building blocks.

The needs of the seven small firms were centered on problem solving assistance. Typically, the number of problems was small, but the degree of assistance required was substantial. The pattern which seemed to evolve was that of an extensive information seeking effort on a given problem following a period of analysis and evaluation on the part of the company. Limited technical resources and scope of operations held down the number of requests.

ARAC's integrated set of services combined with extensive personal assistance by the ARAC staff seemed to work well with the types of problems presented by the seven firms. Selective dissemination of information services were of limited usefulness since must of the firms were too busy with day-to-day problems to be concerned with maintaining "current awareness" in relevant areas of technology.

As a group, the firms reacted very favorably to ARAC's revised fee schedule (effective November 1, 1966). The general feeling was that the charges were modest in terms of the services and assistance provided.

While the results of the experiment were quite encouraging, a number of problems were identified. Most significant was the fact that only two companies continued to utilize ARAC services as fee paying customers. Later a third company became an ARAC member firm. This was most discouraging in terms of effort expended on the seven firms and the apparent results achieved.

It is difficult to pinpoint the reasons for most of the firms' decisions not to continue as fee paying customers. Two factors seem relevant. First, the business instability of certain of the companies undoubtedly was a causal factor. Severe staff reductions were made in two of the firms. The second factor is coupled to the first. Lack of technical capabilities resulted from staff reductions in two of the firms. A third firm apparently didn't have the capabilities to begin with.

Two of the companies were primarily engineering, consulting, and service firms. The information transfer potential for these types of companies seems limited particularly in the engineering service area. These companies typically reflect highly unstable employment levels.

The NASA information base posed problems in a number of cases. Frequently, it was necessary to supplement NASA information with DOD, AEC, and other information sources. While this problem exists with many of the companies served by ARAC, it is more acute with small firms because of their limited information resources and internal information processing capabilities.

The future potential for the transfer of technology to the small business sector appears very promising based on the results achieved through this experimental program. However, as indicated above, a number of problems have been identified.

Recognizing the limited technical resources of small firms and the tremendous reservoir of technology available, it would seem inappropriate to discontinue efforts to make externally generated technology available to these companies. The formulation and development of effective technology transfer concepts and mechanisms is an enormous task. This modest experimental program has, at best, uncovered a number of problem areas and promising avenues for further experimentation. NASA and SBA have, partially due to the positive results of this experiment, continued a number of other projects aimed at effecting technology transfer to small business.

On the following pages the approach taken in this project is discussed in detail. The problem areas uncovered are analyzed in terms of how they might be overcome. A number of areas which seem appropriate for further investigation are indicated. Finally, a number of specific recommendations for follow-on-action are made.

Approach Taken

A close working relationship was developed early in the program between SBA representatives and the ARAC staff. A one-week orientation and training internship was held during the week of February 14-18, 1966, for two SBA personnel.

The internships were aimed at aiding the SBA representatives to: (1) effectively select small business firms to participate in the experiment; and (2) equip the men to serve as continuous catalysts for technology transfer between the companies and ARAC.

This one-week workshop was designed to enable these men to understand, in depth, ARAC's capabilities, operating practices, and limitations. The men were quite enthusiastic and made a sincere effort to understand ARAC's operations. Recognizing time limitations, the sessions seemed to accomplish the objectives established.

Unfortunately, the lack of technical background on the part of the two men prevented them from assisting as technology transfer intermediaries during the year. However, this was recognized in the beginning, and to the degree possible, this role was assumed by ARAC.

One day discussions were held individually with each of the seven companies. Each firm sent one or more people to Bloomington for these briefings. SBA representatives accompanied them. The company people were given detailed explanations of ARAC's information transfer capabilities. they provided extensive explanations of their operations, capabilities, and technology interests and needs. At the end of each session an operating relationship was established.

The management of ARAC made a special effort to emphasize the importance of the NASA/SBA project to each staff member. A number of operating guidelines were established. They are listed below:

1. Carry each request as far toward the application of relevant information as possible.
2. Utilize as many information sources beyond the STAR/IAA base as are necessary to place in the company's hands relevant information.
3. At the outset, explore each problem in depth with the company contact man; follow it up to a satisfactory conclusion.
4. Keep detailed records of all contacts.
5. Maintain a regular contact pattern with each company.
6. Bring all problems to the immediate attention of ARAC management.

ARAC's set of integrated services was used as the basic transfer medium. However, every effort was made to provide flexibility and a customized response to company information needs. Each staff member was encouraged to suggest more effective transfer approaches and mechanisms during the experiment.

Periodic meetings were held during the project with SBA representatives to discuss progress and problems encountered. Continuous analysis of the program was accomplished by ARAC management.

Problem Areas

As indicated earlier, a number of problem areas were identified during the experiment. These can be divided into two groups: (1) those which probably cannot be resolved and thus serve as constraints on any technology transfer effort associated with the small business sector; and (2) those which can possibly be resolved or at least modified via appropriate action.

(1) Constraints

General business instability and inadequate financial, managerial, and technical resources seem to be inherent characteristics of the small business community. This is evidenced by the large number of business failures in this sector. Any selection of firms from this sector for technology transfer action must consider these constraints.

The costs of serving these companies on a unit basis are higher than for larger companies. For example, a retrospective search (RSS) may cost three to six times as much as a regular search of STAR and IAA. Thus, the current RSS charge of $125 in the ARAC fee schedule may run on the average from $400 to $800 for companies in the small business sector. They want and need more than "finding" assistance; their needs border on consulting inputs.

There seems to be a threshold point below which technology transfer efforts would be ineffective and perhaps inappropriate. The list of selection criteria provided earlier may be useful in eliminating firms that are not above the threshold point for technology transfer. It is important to note, however, that in certain cases these criteria are exceedingly difficult to evaluate for a particular company.

(2) Resolvable Problems

The STAR/IAA information base is inadequate in many cases in meeting the needs of small business firms. It does provide an effective component of an information transfer effort. This problem seems to be a result of the relatively low level of technical sophistication in many small firms.

At least three alternatives to coping with this problem are possible First, appropriate technical sophistication and compatability with the NASA information base could be made conditions necessary for selection of firms. However, to do this would eliminate many firms where an apparent technology transfer potential exists. Additionally, those firms selected might possibly already be effectively linked with the NASA technology.

A second possibility would be to rely upon the firm's internal information seeking and processing capabilities. Thus, the ARAC type information transfer effort would provide only a part of the firm's inputs of externally generated technology. This approach has been found feasible for large firms. However, it is not possible for many small firms.

A third possibility is to broaden the information base. In effect, this was done on a selective basis in handling many of the problems of the seven firms in the experiment. This seems to be the most likely approach if it can be done in such a way that costs are held at a reasonable level. Development of the RDC network system with its expanded resources seems to be a workable solution to the problem of a broader information base.

Another problem area uncovered in the experiment concerns non-technical areas. Many of the firms expressed a strong interest in marketing and management. ARAC's Marketing Information Service was well received. Although the Small Business Administration is active in the managerial areas at present, it would seem appropriate to re-examine small business needs in these areas.

Small businesses, of necessity, focus on day-to-day problems. However, it seems important that some means be found to feed new ideas into these companies. ARAC's Industrial Applications Reports and the NASA TECH BRIEF's are helpful in meeting this problem. Yet, additional inputs seem appropriate. Selective dissemination is designed to accomplish current awareness. Perhaps the Standard Interest Profile can offer a possible current awareness input to small firms at modest time and dollar investments.

The information needs of small businesses frequently require consulting type assistance. This is not only expensive, but also requires a staff of applications experts typically not found within an RDC or, for that matter, on a university faculty. Faculty back-up can sometimes be helpful. However, these needs are usually of the type that are not challenging to research oriented faculty people.

Assuming the small business community is willing to pay for such assistance (and this may well be a false assumption), a referral system may be an appropriate means of handling these kinds of problems. Certainly, this is an important problem area which deserves additional study and analysis.

Area for Further Investigation

A number of findings have resulted from this experiment. Also, several additional questions have been raised. These suggest areas for further investigation and experimentation. Several of the more important questions are listed below:

1. What factors or characteristics relative to a small business suggest it as a potential candidate for technology transfer?
2. What is the nature of a small firm's technology needs? Do these needs simply focus on day-to-day problem solving or is the situation more complex?
3. What are the relevant scientific and technical information

sources for small firms? Do they differ significantly from the industrial community at large?

4. How far should the external technology transfer intermediary go in attempting to help the small firm apply externally generated technology?
5. Recognizing the apparent costs of transferring technology to small firms, is this an area for continued government subsidy?
6. What should the role of the government be in technology transfer? Should it go beyond a function of finding likely candidates for technology transfer?
7. What sort of cost/benefit analysis is appropriate in getting at a measure of benefits generated and the costs related thereto?
8. Are the differences experienced in working with small firms as compared to large ones variations in degree rather than kind?

These questions seem significant in considering areas for further investigation. The modest, but encouraging results of this experimental project suggests that additional experimentation should take place. A number of specific recommendations for follow-on action are indicated in the next section.

Recommendations

The small business community is an important segment of the economy. It is a potentially powerful area for utilizing externally generated technology. Yet, small business firms pose complex problems in effecting information transfer. While on the one hand new technology is vital to their growth and, in many cases, their survival, on the other hand, typically, they are not equipped to capitalize on new technology.

One could no doubt defend on a logical basis that this area is too complex for attempting to accelerate technology transfer. However, if technology transfer is to be aided and accelerated for the industrial community at large, it seems particularly important to work toward more effective means of aiding small business firms. Several recommendations for future action are indicated below.

This experiment was one of three RDC efforts. It is important to draw together this entire base of experience with the objective of identifying common findings, recurrent problems, and promising avenues for further investigation. A task force approach to attacking the problem may be indicated if technology transfer to small firms is a useful way to proceed.

The question of a continued subsidy for technology transfer to small firms should be studied further. This refers to a one-to-one type of relationship between external transfer agents and the industrial firm.

Very little is known concerning the characteristics of firms where technology transfer is promising. It is recommended that the criteria listed earlier in this report be analyzed, refined, and made more operational.

A number of the ARAC service elements were found to be useful in transferring information to small firms. One of the ARAC staff engineers who visited and worked on problems with several of the firms has suggested the following approach:

> Sell them a service for $800-$900 per year. Base it on the weekly IAS mailings--there is no longer a reason to think of IAS as a secondary or supplementary service. It is well-received, and it can serve one of the functions which SDS serves--to keep the ARAC name in front of them. Even a very small company could use two or three copies. In addition, each company would be allowed to submit a limited number of searches during the year. These should be called 'Technical Information Searches' or some other names besides 'Retrospective Searches.' They could be used either as 'problem-solvers,' searching the entire file, or as 'up-daters,' being run at pre-arranged intervals serving a function similar to SDS.
>
> For example, a company might be allowed to submit ten searches. It might choose to use four of its ten in a prime interest area such as numerical control--one search of the entire file at the start of the year and one every four months during the year. These could be set to run without requiring a new form to be initiated whenever desired. It might be necessary to say that searches resulting in more than 'X' abstracts will count as two searches to keep costs in line.
>
> I think this or a similar plan which allows some benefits of SDS and RSS can be sold. But SDS on a two-week basis, as we now know it, should not even be proposed to these companies. Also, it is essential to think in terms of an entire information service, including speedy document service, when dealing with these companies.

Beyond this basic service package, the need for applications assistance remains. Some sort of a referral system is indicated to place companies in contact with specialists when such assistance is required.

The role of the Small Business Administration should be examined further. Considering the apparent effectiveness of the ARAC Industrial Applications Reports, the SBA might want to provide this service on a nation-wide basis to a large number of small business firms. On a volume basis the service could be provided at relatively low subscription rates.

CHAPTER VI: SELECTED ARAC TRANSFER EXAMPLES

Achieving a quantitative measure of the economic impact on any given firm of ARAC's technology transfer systems is virtually impossible. Primarily this is because: (1) R & D is one of the most sensitive areas of industrial security, (2) the time span between the generation of a new or improved product or process and its commercialization typically involves several years, and (3) the information inputs received by a firm in connection with technological advancements are varied and from a multitude of sources, thus rendering the portion contributed by ARAC unmeasurable. In spite of these difficulties, ARAC has documented a number of specific transfer case histories. There seems to be a direct correlation between resources expended in seeking transfer case histories and the number of transfers documented. The 1969 evaluation of the State Technical Services program by Arthur D. Little Company should serve as ample evidence that numerous transfer case histories can be uncovered if sufficient resources are allocated to this task. Naturally the research and identification must be done very carefully with highly credible researchers and research techniques. The question which needs to be addressed is whether or not allocation of significant resources toward these activities is warranted when there is so much that still needs to be accomplished in improving the action program portion of technology transfer efforts. The managements in ARAC user firms consistently state that the greatest impact ARAC has made is that the Center has awakened these firms to the concept of seeking new technology/information in an organized manner from sources external to the firm. Many ARAC user firms have established special departments for this purpose. Methods of measuring this impact must be devised.

As a general rule, it is very difficult to identify specific instances of transfers of technology. The following quotation from a letter from one of ARAC's member companies exemplifies this problem.

> I want to express our appreication for the fine job ARAC did in the product and market evaluation of radiation pyrometers...We are not in a position to reveal the status of our investigation in this field...

The one thing which ARAC must hold sacred is the companies' proprietary positions. Each ARAC staff member is obligated to sign the so-called ARAC "secrecy agreement" as a prerequisite to employment at ARAC. Essentially, this agreement states that no ARAC staff member will divulge or discuss the technical information needs of a firm with anyone outside the organization. In cases where ARAC technical staff members seek assistance on problems from sources external to the Center, the company's identification is not disclosed and the assistance is sought in such a manner that only the minimum amount of detail is specified. Even though ARAC serves a variety of industrial firms, many of whom are direct competitors, there have been no incidents of disclosure of proprietary information in seven years of operation at ARAC. Unfortunately, many outstanding transfer examples must go unheralded because of trust placed in ARAC by user firms. It is, therefore, necessary in many cases only to talk about the nature of a transfer without being specific in identifying it.

There are, however, a number of specific instances where transfer of technology has occurred and the company has given permission to reveal the transfer. Consequently, this chapter is a mixture of anonymous and detailed accounts of technology transfers which have been facilitated by the activities of ARAC.

The first section summarizes the effectiveness of the Selective Dissemination Service. The next section discusses some transfers which have been identified but with which, for various reasons, both stated and unstated, the companies do not wish to be identified. The next section contains discussions of confirmed transfers. In each case, the member company involved has authorized public disclosure of the transfer. The transfers involve process innovations, testing techniques, improved design methods, etc. As is usually the case, a complete new product is not transferred--only bits and pieces of technology. The final section contains excerpts from retrospective search feedback forms which have been returned and have indicated a transfer of one form or another.

TRANSFERS THROUGH SELECTIVE DISSEMINATION

ARAC has a large number of Custom Interest Profiles (CIP) comprising an important part of the Center's current-awareness activities. Notifications sent to recipients of these profiles are originally identified by monthly or twice monthly computer searches of the latest issue of the various machine-readable technical information files received at ARAC. After the abstracts thus identified have been reviewed in the light of other parameters which it is not possible to build into the computer search strategy, a final selection is made for dissemination. Along with this deck of abstracts representing the output of the CIP's an evaluation sheet is sent. In some instances, the evaluation sheet is not returned. When the sheet is returned, feedback is most helpful.

Defining relevance of documents identified (and subsequently ordered either through ARAC or company channels) as evidence of transfer of technology, there is a very high index of transfer from this phase of the ARAC operation. The information contained in Table 6.1, taken from a small in random sample of the profiles, gives an indication of the level and type of relevance being experienced. The data in Table 6.1 were gathered over a three month period and the relevance rating was determined by the user based on feedback forms sent with custom profile output. It is significant to note that in a large number of cases either partial or full solutions to problems are being provided through this service.

Occasionally the recipient of the abstracts returns personalized comments on these evaluation sheets. Some of these are:

> I like it. Several things have been spotted which I would otherwise have missed. Thus, I can relax somewhat on reading abstracting journals.
>
> One article may possibly provide a partial solution to the problem.

Table 6.1

CUSTOM INTEREST PROFILE RELEVANCE

Technical Area	% Relevance	Comments Regarding Usefulness
Mechanics	70%	General Information on the Subject.
Bioengineering	45%	General Information on the Subject. Partial Solution to a Problem. Information not requested but of interest.
Bioscience	75%	General Information on the Subject. Partial Solution to a Problem. Information not requested but of interest.
Electro-Mechanics	75%	General Information on the Subject. Partial Solution to a Problem.
Consumer Products Electronics	25%	General Information on the Subject.
Stock Removal	75%	General Information on the Subject. Full Solution to a Problem.
Semiconductors	70%	General Information on the Subject. Information not requested but of interest.
Flame Plating	50%	75% General Information. 25% Partial Solution to a Problem.

Excellent set of references. I will probably be able to cut down significantly on my own literature searching activities.

Picked up several references so far which I have missed.

The following comments are quoted from a special report prepared by W. D. Snively, Jr., M. D., of Mead Johnson & Company.

Twenty-four of the originals (documents) requested from ARAC pertained to mathematical or operations research techniques and one pertained to computer programming. I would estimate that at least one half of these references could prove to be useful in future projects...

...About half the references supplied...are of general interest...and, of course, those for which copies are requested are applicable directly to the research being conducted by requesting scientists...

ANONYMOUS TRANSFERS

ARAC periodically conducts aduits of a sample of scientists and engineers in companies using ARAC services.

Below is a summary of the specific instances of technology transfer which were obtained. Because the companies involved have not given permission to disclose their names, they will have to remain anonymous. One man said he could think of seven or eight examples, but did not want to talk about them. This is not a new experience for ARAC.

1. ARAC information contributed to designing analytical tests for toxicity of combustion products from burning plastics.
2. Information was found to help evaluate the use of a light pen on a cathode ray tube. No product resulted because they determined that the current state of light pens was such that they cost too much to use. Nonetheless, the value of the information obtained saved time in making their own evaluation of light pens.
3. Reports were obtained which provided valuable information on theory and technique of growing ruby and sapphire crystals for lasers.
4. Information was obtained leading to the use of new foamed insulation for cryogenic application. These were used both on cryogenic storage tanks and on cryogenic transfer lines.
5. Reports obtained were used in the design of a liquid helium bubble chamber.
6. ARAC references were used to obtain information on heat transfer through vacuum. Two dimensional heat radiation in a vacuum was the problem of specific interest.
7. A search of government reports done by ARAC was useful in designing a program for selection and training of employees to repair electronic equipment.

8. A special document from ARAC provided government test data on a new experimental product (the interviewee refused to discuss it further, and it was felt that a competitor's product was what he was referring to).
9. An abstract of a report which was obtained from ARAC, was responsible for introducing the company to a thin film transducer particularly useful for ultrasonic detection.
10. One individual mentioned that a survey on crystal nucleation had been of value to the company. He did not comment more specifically.
11. Another interviewee mentioned that his firm uses consultants a great deal. They sometimes use ARAC searches of government reports to find out who is active in a field of interest. This partially serves as a search process for finding a consultant.
12. A report from ARAC was instrumental in a solution of a filtration problem. The product on which the problem occurred is believed to be a new one, but the interviewee did not comment further.

CONFIRMED TRANSFERS

This section contains examples of transfer of technology which have been authorized for release by ARAC member companies. It is in no way implied that these are the only examples identified--rather these are some which have been released for publication.

Included are:

- New Welding Process
- New Solvent
- New Test Method
- New Material
- Life Expectancy Estimate
- New Product
- Design Techniques
- Product Reliability Improvement
- Refrigeration Equipment
- New Supply Source
- Design Data (2)
- Probability Distributions
- Computer Techniques
- Holding Fixture

New Welding Process

Company

Hoffman Specialty Manufacturing Corporation

Problem

Find improved methods for joining thin metal (.004" to .006" thick).

Solution

Hoffman was using soldering for a particular thin metal joining operation. They were interested in better techniques for doing this same job. An ARAC retrospective search identified the Tungsten-Inert-Gas (TIG) welding process. Since then other searches in this area have supplied them with valuable operating parameters for best performance of the equipment. They have currently obtained two welding machines and after a period of further testing and training plan to purchase more equipment for introduction into their production operation.

Value

This technique will eliminate several component parts now required in the assembly.

It will affect a significant man-hour saving on the assembly line.

It extends the usable temperature range of the manufactured part.

It provides an inhouse capability to manufacture component parts which were previously purchased.

Although no monetary value has been assessed, this is obviously worth many thousands of dollars.

New Solvent

Company

Mead Johnson & Company

Problem

Periodically it is necessary to remove lithography from cans of various products, in the course of conducting consumer acceptance tests and taste-panel work. The removal was accomplished using chloroform and steel wool, which was a slow, hazardous task.

Solution

ARAC Industrial Applications Report number NASA-225 (NASA accession N64-20321) described a paint remover which was "more efficient and more universally applicable" than the existing systems on the market. They had tried many solvents and removers without success. On their request, ARAC provided complete information by sending a copy of the document. After careful study, they selected an efficient alternate formulation which contained only immediately available chemicals.

Value

The use of this innovation will save Mead Johnson & company several thousands of dollars annually.

It will eliminate a hazardous operation with regard to health.

In addition, it has potential applications in plant maintenance.

New Test Method

Company

Sarkes Tarzian, Incorporated

Problem

To reduce the turn-off time of a silicon controlled rectifier.

Solution

They produce a silicon controlled rectifier whose turn-off time is approximately 100 microseconds. Document number AD 430901 referred to several ways that the turn-off time of such silicon-controlled rectifiers could be changed. As a result of the techniques discussed in this document, their device number 5TCR was tested at turn-off times down to 50-60 microseconds. This device is thus usable over a wider frequency range.

Value

If the company had decided to attempt such an experiment without benefit of the document, it would have taken approximately two months of research time by their engineers. With the information given in the document, however, their tests were completed in two days. This alone is worth perhaps $5,000 without considering the increased market potential of the 5TCR device.

New Material

Company

Esterline-Angus Instrument Company

Problem

To locate a material capable of accommodating high density magnetic fields for use as a core material in a pen-drive mechanism.

Solution

Esterline-Angus developed a magnetically driven servo recorder with only one moving part. The pen, on a drive coil, slides along a one inch diameter core piece in response to a variable magnetic field. They wanted to produce a model that would handle a larger chart by extending the length of the core piece without changing the diameter. In this way, no retooling would be necessary.

A retrospective search on high flux density materials was performed by ARAC. This search identified a material that would satisfy the flux requirements, but it cost over 70 times as much as the material currently in use. They were able to ascertain from the documents, however, that no low cost material existed that would operate at the desired flux densities. Thus, they are able to proceed, without further research or experimentation, confident that retooling is necessary to produce the new, larger model.

Value

An unnecessary R & D project was avoided.

The company estimated savings in excess of two man months.

Life Expectancy Estimate

Company

Texas Gas Transmission Corporation

Problem

The company was evaluating the use of gas turbine-driven compressors as power sources for system expansion programs instead of conventional reciprocating gas engine units. The main component of the gas turbine compressor is a standard jet aircraft engine widely used in civil and military aviation. The company desired information and data pertaining to the life expectancy of these gas turbines under conditions of static, continuous use.

Solution

After a search of NASA literature yielded no relevant results, ARAC contacted several of the specialized information sources available. Several persons at Wright-Patterson AFB were contacted who had been engaged in testing the type of jet engine in question for many years. Although they had no data relating to static continuous conditions, they did provide valuable information and an estimate of the minimum life.

The Technology Utilization Officer at Lewis Research Center was then contacted by ARAC. A meeting was convened at the Lewis Center attended by representatives of NASA, the jet engine and manufacturer, Texas Gas

Transmission Corporation and ARAC. The purpose of the meeting was to discuss factors affecting the life of the engine and to try to arrive at a suitable life expectancy. NASA engineers thoroughly familiar with the engine were available as impartial consultants. The meeting resulted in the transfer of much valuable information relative to life expectancy. The manufacturer also volunteered to collect and provide much additional historical data.

Value

Texas Gas Transmission Corporation was aided materially in the development of life expectancies for the economic evaluation of the equipment in question.

The meeting at Lewis also generated further interest in the subject of lubrication of the new equipment.

New Product

Company

Esterline-Angus Instrument Company

Problem

Esterline-Angus is seeking new writing methods which can be utilized in the development of a unique product in their line of recording instruments.

Solution

Complete details concerning the proposal were discussed between Esterline-Angus development engineers and ARAC staff engineers. As the results of a retrospective search and the creative ingenuity on the part of ARAC and Esterline-Angus engineers a report was identified in the area of micro-encapsulation which has direct implications toward a unique approach to their problem.

Value

While it is too early to measure positive results, Esterline-Angus' management is highly enthusiastic concerning the possibility of a unique new product resulting from their effort. They indicate that their own people, due to their areas of specialization, would probably have never investigated the approach which was identified through NASA's scientific and technical information combined with imagination applied by Esterline-Angus engineers stimulated by the creative suggestions of ARAC engineers.

The company already estimates significant savings in search time for new product ideas.

Design Techniques

Company

Cummins Engine Company

Problem

Improve design techniques.

Solution

Through the Selective Dissemination Services and Industrial Applications Service provided by ARAC, Cummins was made aware of the "Advanced Bearing Technology" report (NASA SP38). They subsequently used information from several chapters to revise and expand their computer program for bearing designs.

Value

Undetermined.

Product Reliability Improvement

Company

Sarkes Tarzian, Incorporated

Problem

Product reliability improvement.

Solution

As a result of a publication discussing and illustrating causes of failure in semiconductors, they were able to pinpoint the cause of failure that had been creeping into one of their devices. As a result, the reliability of one of their semiconductor devices was greatly improved.

Value

Any dollar value assigned to this transfer of technology would be purely speculative.

Refrigeration Equipment

Company

Cummins Engine Company

Problem

What is the state-of-the-art in cooling equipment for mobile vehicles?

Solution

ARAC performed a retrospective search to locate literature on the cooling techniques used by NASA in their astronaut transfer van as well as other mobile cooling units. This company has now entered the mobile refrigeration market.

Value

Undetermined.

New Supply Source

Company

Esterline-Angus Instrument Company

Problem

Sole source supply of critical part.

Solution

One of their products contains a potentiometer constructed with certain conductive plastics. When the device went into production, they had only one supplier of the component. As the recorder began to sell well, they became uncomfortable with only one supplier and no knowledge of any other similar devices on the market. An ARAC search on this subject revealed that there were indeed many firms and scientists working in this field. As a result of this search and some subsequent follow-up, they will soon approach another potential supplier for a bid.

Value

Undetermined.

Design Data

Company

Hoffman Specialty Manufacturing Corporation

Problem

What are the scaling laws for certain water line control elements?

Solution

Hoffman was considering expanding their line of water line control elements. They were not able to ascertain the operating conditions in this new area. An ARAC retrospective search identified theoretical information to explain the phenomena and several sets of data which were very helpful to them in their design calculation and application of the control elements.

Value

Undetermined.

Design Data

Company

Esterline-Angus Instrument Company

Problem

To produce a low noise, all solid state amplifier.

Solution

The desired amplifier must operate under specifications of low noise, low level, and high input impedance. The production of an all solid state amplifier would require the use of field effect transistors. A search of this topic by ARAC revealed that no transistors of this type were available with performance records within the required specification of reliability and stability. The company engineers, without further research, were able to state that the design specifications could only be satisfied by a hybrid amplifier. The resultant amplifier which utilizes one tube has turned in an extremely reliable performance record.

Value

Undetermined. This work was accomplished before field effects transistors appeared on the market.

Probability Distributions

Company

International Harvester Company, Manufacturing Research

Problem

To obtain ideas on techniques used in ascertaining peak amplitude probability distributions from special analog-digital computers.

Solution

A retrospective search on special analog-digital computers was performed by ARAC. This search gave us confidence and ideas in applying the use of our own peak distribution analyzer in the development of our automatic method for non-metallic inclusion rating of ferrous and non-ferrous materials.

Value

Unnecessary manpower in R & D work was avoided.

The company's estimated savings were approximately three man months labor cost.

Computer Techniques

Company

International Harvester Company, Manufacturing Research

Problem

To apply computer techniques to the desien and ooeration of induction billet heating systems.

Solution

An ARAC search indicated that the AEC, Hanford, Washington installation had developed such a technique. This fact indicated the feasibility of such an approach and a request was made for the AEC data.

There was, however, a delay in the arrival of these data; therefore, the Research Unit concerned initiated a project of its own involving the materials used by the company and the computer most available to it. The program from the AEC has since arrived and will be compared with the Harvester program as a validity test and check where possible, as well as for evaluation purposes.

Value

Indeterminant at present. The very existence of the information, as disclosed by ARAC, allowed and motivated our facility to proceed with a plan of its own. The inherent value will be determined in the future.

Holding Fixture

Company

Link-Belt Company

Problem

Holding soft metal specimens for polishing on a vibratory lapping machine.

Solution

As a part of the regular weekly mailings in the Industrial Applications Service, NASA Tech Briefs are included. One such Tech Brief described a method for holding the soft metal specimens. Link-Belt modified the design to fit their own situation, built a holding fixture, and are now able to successfully polish soft metal specimens on a vibratory lapping machine.

Value

Undetermined.

RETROSPECTIVE SEARCH FEEDBACK

Between January 1, 1967, and April 31, 1968, ARAC performed 684 retrospective searches. Along with the output for each search an evaluation form is sent to the requestor. Only 15% of these forms are filled out and returned. Hence, one must be cautious drawing any generalizations from the feedback.

However, 31 evaluations were received which indicated a transfer of one form or another. The nature of the transfer and the comments for each of the 31 evaluations may be found in Appendix D of this report. As may be noted by reading the specific comments, there are few cases when a retrospective search will supply a complete and perfect solution to a problem. Usually the retrospective search will turn up information that supplies a partial answer employing the method originally in mind for solution , or will turn up information suggesting alternate approaches for solution of the problem at hand.

CHAPTER VII: ARAC CONTRIBUTIONS TO INFORMATION SCIENCE: STANDARD INTEREST PROFILE DEVELOPMENT

When the ARAC experiment was first conceived in 1962, the entire operation was approached from an economic growth viewpoint. Little thought had been given to the information science aspects of operating an information transfer center. Soon after operations with user companies began in the Spring of 1963, it became apparent that utilization of the best information retrieval techniques would lead to reduced internal operating costs and increased efficiencies. Accordingly, some effort was devoted to research in information science. Any work done at ARAC which could be considered research on information science was undertaken from a very parochial viewpoint rather than with a basic research attitude. The research and development was undertaken with the objective of reducing internal costs or improving the quality and timeliness of ARAC information products. Important developments include the following:

1. A Comparison of Systems for Selectively Disseminating Information.[11] This was the original piece of information science research done at ARAC. Four different methods of retrieving relevant items from a large machine-readable document corpus were studied with an objective of ascertaining the most suitable system in terms of cost/effectiveness. The study showed conclusively that retrieval of relevant items via weighted-term computer strategies was superior in the ARAC environment.

2. Development of A Hybrid Man-Machine Information System.[12] Two extreme cases exist for operating information retrieval systems. At one extreme, all operations are done by computer including searching, sorting, printing, and mailing of the product. At the other extreme, all operations are done manually. A study made in the ARAC environment showed that only the searching and sorting should be done by machine with the remainder of the operations done manually in order to achieve optimum cost/effectiveness.

3. Development of A Universal Computer Search Program and Standard File Format.[13] The simplicity of this concept should not detract from its significance. Basically, it involved the development of a high quality, generalized computer program based on the weighted term approach that would select relevant items from a large document corpus. The program is designed to operate on a certain file format. As new technical information files become available, they could be rearranged into the same standard format. This allows the searching of practically any new information file with only the relatively low cost associated with placing the file in a new format rather than the high cost of developing a new computer search program for each new file.

4. Development of A Cost System for Information Centers.[14] This study involved delineation of important cost variables involved in the operation of an information center. Knowledge of internal costs provides a basis for decision making to the center's

management as well as a method of arriving at an equitable fee schedule for services. Important elements of this study are described in Chapter IV of this report.

5. Automated Maintenance of Current Awareness Profiles.[15] It was shown in Chapter IV that internal costs in operating a current awareness service are directly proportional to the number of abstracts the ARAC technical staff must evaluate. The costs are roughly the same whether the abstract is judged relevant and sent to the user or if the abstract is deemed irrelevant and discarded by the ARAC engineer. A computer program system was developed that makes elementary decisions and tells the ARAC engineer how to revise his profile strategy so that irrelevant selections are minimized.

As mentioned above, each of these developments was critical to the operation of ARAC's information system. Another concept, standard profile development, had some significance on internal ARAC operations in that it allowed reduction in the number of staff members assigned to the ARAC current awareness services. The primary significance in the development of standard interest profiles was from the user's viewpoint in that it provides a high quality, low cost form of current awareness service. The remainder of this chapter describes the standard interest profile concept.

To appreciate the nature and potential effectiveness of what is commonly called a Standard Interest Profile (SIP), it is useful to view this terminology in the context of its origin, i.e., current awareness services in general. In this subject matter category, the most commonly recognized term is selective dissemination of information or SDI as labeled by a major computer manufacturer.

What is a current awareness service, and what useful purpose can it serve? Both of these are justifiable questions and should be answered before attempting to describe one of the most recent innovations with respect to SDI services. Current awareness is an information service designed to keep its users up-to-date with any and usually all new developments in a knowledge area that a user designates an representative of his field of interest. Anyone who has experience with the rapid pace at which information is being generated can appreciate that a service capable of reducing the vast body of developed knowledge to some readily usable, refined package of information that can be reviewed in a matter of minutes is desirable. The need for being able to do just this is precisely why such services exist. A detailed look at how current awareness services function is in order to appreciate where the SIP fits in the spectrum of current awareness services.

Consider for a minute a system that generates about 2,500 new reports or entities of new information every two weeks. Such systems are not hypothetical; they do exist. The NASA system is one such example. It is a formidable task for an engineer to find his way through a journal that is soundly edited and well indexed, such as Scientific and Technical Aerospace Reports (STAR), an abstract journal in the NASA system. This is particularly true under conditions where his employer simultaneously expects full-time performance on the full-time job. Alternatively, the engineer might go to an information service center such as ARAC and convey his area of interest to an applications engineer or information specialist. The information specialist then attempts to help the engineer to clarify and make explicit his needs and desires, translating these needs into a group of specially chosen subject index terms. These terms serve as input to a computer program which, in turn, searches a magnetic tape where the information is stored. The group of terms that describe the information interests of an engineer is known as a current awareness profile. The computer program recommends those reports or pieces of information which are relevant to the stated needs of the engineer. The computer output of a current awareness profile is effective only to the extent that the information specialist has selected those terms for the profile that are commonly used in the first instance to index the reports of greatest interest and potential to the particular individual.

One immediately realizes that the probability is somewhat low that the person who attempts to retrieve a document in response to a stated information need would choose exactly the same terms selected by another person who indexes a given report for storage. To improve upon this probability, both indexers and specialists in SDI work with a list of authorized terms. This list is called a subject authority list or thesaurus and is used to describe any given document as logically and consistently as possible. The information engineer is well aware of the problem of mismatch between the index terms used in the two instances and will attempt to include in the profile as many terms as he thinks might possibly be related to a given subject area. This inevitably leads to the computer selecting a large body of information which is in some way related to the engineer's information needs but probably not completely relevant. To make the computer output a useful package of information to the engineer, it is necessary to have the information specialist review and edit the computer selected information and remove those reports which are not truly relevant. Thus, the information specialist must also be trained to some degree in the same technical areas as the engineer if he is to make these selections.

There are many variations to the solution of this basic problem. Some systems attempt to create profiles that are very specific to make the information selected by the computer more highly relevant to the particular interests. In doing this, one runs the risk of reducing the total number of relevant reports chosen so that the computer's output is only a fraction of what it might be. This situation is known as reduced recall. Recall or the recall ratio is the ratio of the number of pertinent documents found to the total number of pertinent documents which exist in the corpus or file. An effective service must obviously optimize this ratio.

The type of current awareness interest profile describes above may be called a custom interest profile. It is custom in the sense that the personal interests of a single engineer, or possibly a group, is being served. The information specialist codifies this particular interest for the computer and edits the final output for the particular needs of that individual or group. If one reviews quickly the steps involved in getting meaningful information to the engineer and also thinks for the moment about the quality of person and the type of training necessary to fill the job description of information specialist, it becomes immediately evident that a service such as is provided by a custom interest profile is costly. Further, the main costs reside primarily in the initial definition and start-up of the profile.

If information services are to survive as competitive endeavors, and not heavily supported by government subsidies, the very crucial problem of cost of generating custom interest profiles must be overcome. Fortunately, there exist several alternate cost-saving measures which can be employed. One possibility is to reduce the amount of the very costly personal attention that is put into the particular information service. After a profile is established and performing satisfactorily, the only interactions needed with the user are on occasions when the user's interests change and he wants the change reflected in his profile. There is still the matter of the information specialist editing the computer output of the profile. With the present state of development of indexing and retrieval, it appears that editing the computer output with a good technical mind will continue to be necessary. To achieve further cost reductions, it became necessary to take a businessman's look at the cost situation.

The whole problem is in a very real sense analogous to that of automobile production. It is possible to make very fine, hand-crafted automobiles that are capable of giving several hundred thousand trouble-free miles, but at an initial cost of $20,000. On the other hand, it is possible to mass produce automobiles that are capable of giving 50,000 trouble-free miles at an initial cost of around $3,000. The somewhat less endurable automobile will meet the needs of most people. One must keep in mind that there will continue to exist, in some instances, the need for the $20,000 automobile. This same point of view can be applied to the structuring of current awareness profiles.

By late 1966, ARAC had acquired several years of experience in operating a current awareness system involving some 384 custom profiles. An analysis of the types of information needed by this sample of users indicated that many had very similar interests. In view of this, it seemed possible to structure a limited number of profiles that could meet the needs of a great number of users. If, for instance, thirty people could be served for the price of one profile, the reduction in costs per user would be very substantial and the information center's potential for handling new users would be greatly increased. Further, whole information services would be in an economically viable position. Thinking and development along just these lines have led to the concept and creation of the Standard Interest Profiles.

Based on the experience of ARAC in the area of Custom Interest Profiles and its continuing interaction with almost all segments of the industrial sector of our economy, Standard Interest Profiles were defined in several critical areas. The logic behind the development of each SIP topic has been to segment a potential market for current awareness service to match areas in which a sufficient volume of reports are regularly released in the literature base so as to make service feasible. The goals for each SIP topic are:

1. To provide reports on topics known to be of interest to someone working in private industry. In many cases, ARAC knows of people who want and can use the material. In others, the selection of SIP topics was done by inference--an ARAC staff member knowing by experience that someone out there ought to be interested in a set or series of reports he had seen.

2. To provide mailings of convenient size. The objective was to have each profile mailing average not less than 5, nor more than 50 abstracts so that recipients would neither feel cheated nor overwhelmed.

3. To provide prospective users with accurate descriptions of what they could really expect to see as a result of using the Standard Interest Profile. In other words, try to group technical interests into areas where a stream of literature appears to be coming from the literature base, and describe what this stream is as accurately as possible.

All of this is a subjective process which has incorporated in it all of the pitfalls of stereotyping prospective users, making compromises which do not entirely satisfy the needs of any individual users, and making relevance judgements which may not be universally accepted. On the other hand, the SIPs help a great deal with three of the major problems of a current awareness abstract service which is done completely on a custom basis. These are:

1. The establishing and maintaining of a congruence between a user's interests and what is in fact available to him, is a tedious business. Few clients know enough about the literature base ARAC uses to match its contents to their problems for current awareness. They frequently want to be told what they should ask for. The SIP descriptions have helped considerably in outlining to non-aerospace personnel what is available for them to select. New Custom Interest Profiles are now rare, and are developed only on the suggestion of the ARAC staff or by persons with knowledge of the literature base and whose self-definition of their technical interests is unusually well-developed.

2. Keeping the scope of customized topics within reasonable bounds has often been difficult. Users like to route them--then add to the subjects covered to "provide something for George." Sometimes this process evolves to a point where the user abandons interest or is transferred, leaving "George" with a profile which cites a great many reports, few of which are really of interest, and "George" does not know what to do with it. By having ARAC staff members define the topic areas, the size of the profiles stays reasonable, and the sub-topics retain a logical relationship between each other.

3. Because of the problems given in points 1 and 2, custom abstracts service for current awareness is expensive. ARAC experience has shown that there are few economies of scale in servicing current

awareness profiles on a custom basis. This is the biggest advantage of Standard Interest Profiles--low cost per customer.

A minimal amount of client contact is required to assure that the reports being cited by SIPs are satisfactorily related to users interests. Checking a few recipients once each six months appears adequate for revision and feedback on the relevance of report citation selections. Nonetheless, the basic objective of SIPs has been market-oriented. Each profile began by assembling a profile of a typical user's interests in a particular technical subject area. Then the literature base was reviewed to determine if there was a sufficient quantity and quality of literature to satisfy the typical user's interests. The points of match became Standard Interest Profiles.

A complete list of SIP titles available from ARAC as of this writing is shown in Appendix C. The first part of Appendix C is a sequential listing of SIP numbers. The second part of Appendix C shows the titles separated into eleven categories. The eleven categories of SIPs are:

- Polymers and Plastics
- Chemical Engineering and Chemistry
- Computer and Information Sciences
- Earth Sciences
- Electronics and Electrical Engineering
- Energy Sources
- Life Sciences
- Management
- Materials
- Mechanical Engineering
- Physics

The list of available SIPs is constantly being reviewed with the intent of removing those for which interest has waned and creating new ones as technological needs indicates.

The acceptance of this innovation by industrial users has been gratifying. At the end of the last quarter of 1966, ARAC was servicing approximately 384 Custom Interest Profiles. At the end of the third quarter of 1967, ARAC was servicing only 114 Custom Interest Profiles. Ending this same period, however, 317 subscribers to some 46 Standard Interest Profiles (only 46 SIPs available at the time) were being served by ARAC. As of this writing the list of SIP subscribers has grown to nearly 1,000. As expected, many ARAC customers recognized that their information needs could be served by a single SIP or properly chosen set of SIPs at a considerable saving over the cost of a comparable Custom Interest Profile. This is possible because the cost of all SIPs is a standard $80.00 per year to member companies, while the cost of a Custom Interest Profile is variable, starting as low as $225.00, but averaging somewhat close to $500.00 per year.

To illustrate the typical reaction to SIPs, a quotation from a trip report to an ARAC member company seems typical:

> Several people indicated that they would like to see changes made, but they were satisfied when we explained the difference between custom and standard profiles and the difference in cost.

No user has reverted back to a custom profile after taking a SIP substitute. At least so far, SIPs have not been discontinued for not being useful, but there have been some cases of topic substitution.

Reactions to the format in which SIP abstracts are presented has been favorable. During a recent audit of ARAC member companies, the ARAC staff found three users who commented that the $8\frac{1}{2}$ x 11 format was much preferred to the deck of single abstracts because it is easier to handle. (The decision to use abstracts rather than computer-listed titles was made at the beginning. The nature of the topics requires editing the computer output, and if only the results of an edit are to be the final output, then abstracts cost little more to print than titles, and they are far more satisfactory to both editor and client.)

All of ARAC's information resources are utilized in assembling the SIPs (see Chapter III for ARAC information resources). Coverage will be expanded as resources allow and as need justifies. However, even present coverage should serve the needs of the broadest possible cross section of potential information users.

Another aspect of the Standard Interest Profile of great significance regards the number of subscribers to a given profile. Naturally, the cost of providing the service decreases as the number of subscribers increases. It is possible to anticipate a time in the future when this high quality information tool will be offered at substantially lower costs than the present attractive rates which, while being low, still limit their purchase to organizational entities such as business firms or universities. The ultimate objective of this concept is to expand distribution to a degree where the annual subscription cost per profile will be roughly equal to the variable distribution costs. When this occurs the annual cost of a high quality current awareness service will be easily within reach of individual technical persons in a manner similar to annual subscriptions to technical journals.

CHAPTER VIII: IMPLICATIONS OF THE TRANSFER CONCEPT

The technology transfer concept has a very unusual and interesting history. This is true not only because it originated as a result of various government programs and philosophies involving numerous government agencies, but also because many transfer programs involved government, university, and industry cooperation. Some of these efforts have been relatively successful. But the concept is a complicated one because it has so many implications. For example, definition of the appropriate roles of the three institutions mentioned above, relationship to economic growth, parameters for measurement of success, relationship to information retrieval, and responsibility for education of the general public to the concept are just a few, and there are a host of others.

Although some social and political advances have been made, many improvements in the quality of life experienced in the twentieth century may be traced almost entirely to technological advancement. Unfortunately, some of our current day dilemmas may be traced to the same cause. A key to maintaining advancement while minimizing the potential resulting adverse effects lies in the appropriate utilization of technology/information transfer systems. Surely the future will belong to those who can effectively manage and utilize the sheer abundance of information already in existence as well as the new findings being added. In 1965, the President of the United States summed up the situation when he said:

> The test of our generation will not be the accumulation of knowledge...Our test will be how well we apply that knowledge to the betterment of mankind.

To date the surface has hardly been scratched in many respects. Among industrial firms, only a small percentage can effectively utilize information. In many federal government agencies and programs the situation is equally poor with regard to effective utilization of information. Among state and municipal government operations, the effectiveness of information utilization is almost non-existant. Even universities have been derelict in this respect. Perhaps J. J. Servan-Schreiber, in his book The American Challenge summed the situation well when he stated:

> The new frontiers of human creativity lie in information systems and their utilization, and the Americans themselves do not seem to fully realize this yet. We must forge ahead into this area before it is taken over by others.

In this chapter, an attempt is made to identify further some of the various implications of effective utilization of information as listed above and relate these to the technology transfer concept.

TECHNOLOGY UTILIZATION AND ECONOMIC GROWTH

While this report is concerned with means of making new technology available to those who can use it, it seems important first to ask if the benefits of employing new technology warrant an investment in the means of making it available. There are indications that it will. Only recently have economists devoted much attention to causal relationships in economic growth. But throughout the literature, one can trace the awareness--by economists and policymakers--of the importance of science and technology in economic health.

More recently, economists[16 & 17] have attempted to measure the contribution of technology to the rate and volume of economic growth. It is estimated that of the total increase in U.S. output per man-hour from 1909-49, only one-eigth was due to the increase in capital investment while seven-eights was due to technological progress. It has been found that, during the 1871-1951 period, technological advance accounted for 90 percent of the rise in output per man-hour (versus 10 percent for capital formation). And that during the 1919-1955 period, technological changes accounted for approximately 90 percent of the rise in output per man-hour.

In studies[16 & 17] of innovation and its effect on the growth of individual companies, it was found that the innovative companies grew much more rapidly (during a 5-10 year period after the innovation occurred) than other firms in their industries. The average growth rate of the innovators was often twice that of the others.

It is apparent to even the most casual observer that advancing technology has drastically transformed the character of man's activity. A century ago, men and animals provided nearly all the musclepower in industry. Machines supplied about one horsepower per production worker. Machines now provide more than ten times that amount of energy. The farm population, in that time period, has decreased from eight in ten to less than one in ten, thanks to increased farm mechanization. And since 1860, the average lifespan has jumped from around 40 to around 70 years, owing to medical advances in the prevention and cure of disease and to gains in sanitation and nutrition.

It is clear that the infusion of new technology can speed the rate of economic advance. But the importance of new technology to society cannot be measured solely by its contribution to our gross national product. GNP measures, with limitations, the output of goods and services in the national economic system. But any realistic assessment of economic performance must also consider how that output is distributed, the ability of the system to make the generation of that output personally rewarding, and the environment--or the quality of life--created by the system. GNP does not measure the economic system's performance in terms of giving people what they really want.

Much of the benefit of the infusion of new technology into the economy is not reflected in measures of productivity. For example, if technology permits the making of a better product without a corresponding change in production costs, the result is not reflected in statistics of output--but is a decidedly beneficial action.

One approach to the full realization of the benefits of new technology is to arrange for its effects to be more widely felt--to be diffused into more industries, more governmental missions, and more regions of the country. In other words, programs to channel new technologies in useful and satisfying directions can have the effect of notably enhancing the rate of economic growth--though the full effect of such programs would likely not be measured by conventional methods.

Studies[16 & 17] have shown that differences in levels of formal education attainment create significant differences in productivity. It follows that differences in practical professional knowledge acquired after completion of formal education can have a similar effect. In other words, the scientist, engineer, or businessman who continued to accumulate new knowledge--via being somehow updated in the latest R & D results in his field--would be more productive than the one who was not. If that logical assumption were indeed proved true, then investment (public or private) in programs to identify, evaluate, and utilize new technology would pay significant dividends in productivity improvement at the level of the firm or end user of the technology.

Many studies of the contribution of technology to economic growth have concentrated on the economic impact of major inventions and innovations. But the most important contributions to economic growth may be stimulated by widespread adoption of incremental improvements. These incremental advances typically result from the knowledge chunks or technology building blocks mentioned earlier in this report.

If incremental advances do play a significant role, then many important economic and social implications exist in this situation. Among them are:

1. Regional Economic Imbalances. With the three states of California, New York, and Massachusetts obtaining approximately half of total Federal funds in recent years for performance of research and development, there is a tendency for industry in those regions to reach a level of technological sophistication far above that possible in some other states. But if the technology resulting from R & D performed in California could readily be channeled into those industries in other areas, the chances for regional imbalances in technological capability would be lessened.

2. Industry Imbalances. The current pattern of R & D fund distributing could also tend to create serious interindustry imbalances. For example, consider the machine tool industry. Its technological health is important to the national defense posture and to the ability of other industries to reach high levels of productivity. But many significant new advances in metal cutting and metal forming have been developed by firms not traditionally part of that industry. A better means must be developed to channel the technical advances made in the aerospace and related industries to the machine tool industry and other basic industries, where such technical advances can be commercialized and in turn contribute to the technical and economic health of still other industries.

3. Timelag. Enlarging the use of new scientific and technical knowledge would contribute to economic growth by reducing

the timelag between discovery of new knowledge and its economic exploitation.

4. International Competitive Position. Early effective utilization of new technology will logically have a beneficial effect on the U.S. balance of payments via increased exports of U.S. goods. This comes about in several ways: (1) cost reductions enabling U.S. goods to be more price competitive in international markets; (2) new products and product improvements can expand overseas markets; and (3) creation of entire new industries whose output can be sold worldwide. International trade implications are discussed further in a subsequent section of this chapter.

Perhaps none of the specific arguments in themselves make a conclusive case for the fact that channeling of new technologies in promising directions will significantly speed economic growth. But the arguments that have been put forth by various students of the question--when examined in composite--make a strong case for the transfer concept. Briefly the individual elements of the case are:

The use of new technology can reduce production costs, thus increasing productivity.

The use of new technology can sometimes permit the output of a wider range of customer-satisfying products and services without a corresponding increase in capital investment, thus raising the return on invested capital and/or permitting price reductions.

The use of new technology can shorten the timelag between the development of new knowledge and its widespread applications, thus spurring the growth process

The use of new technology can enhance the international competitive position of U.S. industry, thus improving our balance of trade.

The use of new technology in the civilian sector--because such new technology will generally be adapted and coupled with other technology to create another sheath of new technology--can in turn provide new technological input to Government programs in space and defense, thus enhancing our defense posture and aiding our international prestige.

The use of new technology in some areas--medical research, urban design, mass transportation, to name a few--can improve the quality of life.

The use of technology in one sector that was originated in another can help to provide a balance in the economy in terms of technological capability, thus avoiding problems that might--though would not necessarily--be created by the concentration of research and development effort in a relatively few companies within a few industries in a few geographical regions.

The use of new technology can stimulate the production of new products, thus creating new jobs.

The use of new technology can reduce the cost (and, hopefully, the price) of producing existing products, thus freeing purchasing power for the acquisition of other products, creating additional jobs in those areas.

TECHNOLOGY TRANSFER AND INNOVATION

Invention and innovation lie at the heart of the process by which America has grown and renewed itself. This simple truth may be expanded by exploring more specifically why there should be concern about the climate for invention and innovation.

First, there is a very significant relationship between innovation and economic growth. Although estimates of the contribution of technological process to increases in GNP are imprecise, economists agree that the contribution is substantial. For example, compare the change in labor input (or total hours worked) with the change in GNP over the period 1947-1965. A marked difference between these two factors will be noted.

The annual hours of work remained practically constant while the GNP rose substantially during the period in question. Indeed, the GNP nearly doubled. Without presuming to say how much of this increase in GNP was attributable to technological transfer and innovation, it may be stated confidently that new technology and innovation played a major role. Of course, data such as GNP are abstract statistical notions. By and large, they fail to excite the imagination, for they do not have the impact of specific examples. It might be instructive, therefore, to look at the histories[18] of three industries which were commercially non-existent in 1945, but over the past 25 years have contributed significantly to the nation's growth. In 1945, the television, jet travel, and digital computer industries were commercially non-existent. It is estimated that in 1970, these industries will contribute more than $20 billion to our GNP and an estimated 1,200,000 jobs. Of great significance, however, these three industries have had a profound effect on the quality of life.

It might be useful to compare the average annual growth of GNP over the period of 1945-1965, with that of some of the companies that have committed themselves to dependency in technological advancement as a way of life and have experienced nearly all of their growth of the twenty year period as mentioned above. These are listed in Table 8.1.[18] While the average annual growth rate of GNP over this period advanced at a rate of 2.5%, the average annual net sales growth of these companies ranged from 13% to 29% and averaged, for the group, exclusing Texas Instruments (due to lack of data) which would have raised the average, nearly 17%. At the same time, the average yearly growth in jobs ranged from 7.5% to almost 18%. Many other technologically innovative companies have had similar experiences. There are other important factors involved which would help explain the growth rate for the companies listed, but certainly dependency on technological advancement as a way of life has been instrumental.

TECHNOLOGY TRANSFER AND INTERNATIONAL TRADE

Consider the effects of technological change on international trade and another very persuasive reason for concern can be found. An important element of our international balance of payment is what is called the "technological" balance of payments. This international account reflects payments for technical know-how, patent royalties, licenses, etc. Data[19] for 1961, indicate that the U.S. paid $63 million to other countries while receipts to the U.S. from other countries totaled $577 million in this category. Therefore, the U.S. recieves roughly ten times as much in technological payments from abroad as goes out in payments to other nations. Indeed, this is a very significant secondary effect of technological advancement in the American economy.

Technological change effects international trade in subtle ways. Consider, for example, the so-called "displacement" advances. These do not have the dramatic result of a new company, such as the Xerox Corporation or an entirely new product or process for which no substitute existed before. The electronic digital computer is a good example. "Displacement" advances displace existing products or processes. The effect of such innovations is illustrated by the invasion of the cotton and wool fiber market by synthetic fibers.

It is difficult to measure the full significance of "displacement" technological advancements in the United States, because such displacement is a domestic give and take situation. However, if the international picture is examined, a better feeling for the significance of these "displacement" innovations may be obtained. For example, a comparison of synthetics with cotton and wool may be made in the yarns and fabrics industry.

It can be seen in Table 8.2 that synthetics, which sprang from considerable innovation, have maintained their share of the international yarns and fabrics market. The total exports of cotton and wool yarns and fabrics have decreased by about a third over the period 1956-1965, whereas the total exports of synthetic yarns and fabrics have increased by over 50%. The export of high-technology synthetic yarns and fabrics has, therefore, maintained the U.S. export of yarns and fabrics roughly at the level it was in 1956.

There are certainly many other examples of the secondary effects of effective technology transfer and innovation. It seems definite that the international stature of a nation with respect to trade (and assistance to under-developed countries) becomes increasingly dependent upon utilization of technology/information and the resultant innovative performance, although it may be at least as dependent on tariffs, legislation on import quotas, etc.

TECHNOLOGY TRANSFER IN THE PUBLIC SECTOR

There are many pressing, public sector problems that require effective use of existing technology/information for solutions. For illustration, a few examples of some of the problems are listed below:

Table 8.1[18]

FIVE TECHNOLOGICALLY INNOVATIVE COMPANIES

	Average % Annual Growth (Compounded) 1945-1965	
Company	Net Sales	Jobs
Polaroid	13.4%	7.5%
3M	14.9%	7.8%
IBM	17.5%	12.1%
Xerox (Haloid Company)	22.5%	17.8%
Texas Instruments (1947-1965 only)	28.9%	10.0%

Average % annual sales growth of above companies: 16.8%

Average % annual growth of GNP: 2.5%

Table 8.2[18]

U.S. EXPORTS OF YARNS & FABRICS

Yarns & Fabrics	1956 Exports	1965 Exports
Cotton-Wool (Low Technology)	$187 million	$125 million
Synthetics (High Technology)	$158 million	$241 million
Total	$345 million	$366 million

Environmental Pollution
Urban Redevelopment
Fresh Water
Poverty
Crime Prevention
Highway Safety
Urban Transportation

Any consideration of the total transfer concept should include analysis of the interrelationships between social and private innovations. Private innovation in the industrial sector, partly because of ineffective information utilization in some cases, has produced conditions which call for social innovation in the public sector. Advances in private innovation are dependent upon the climate provided by social innovation.

For example, the development of the automotive industry and the introduction of various forms of chemical processing have created conditions leading to the pollution of water and air. In this respect, private technological advances have created environmental conditions which call for social innovation. New industrial technical advances requiring additional supplies of fresh water and a substantial number of well-educated workers will depend, in turn, on public sector technological advances. For without improvements in water supply and in our educational system, it would seem that future industrial advance will be limited. On the other hand, improvements in the educational system are at least partially dependent upon innovation in teaching aids such as audio-visual instrumentation. There is a mutual interdependence between social and private advancement.

It is almost universally agreed that much of the technology needed for the solution of most public sector dilemmas already exists. One key to low-cost solutions for many of these problems lies in the effective utilization of existing technology/information.

GOVERNMENT'S ROLE IN TECHNOLOGY TRANSFER

If we accept that it is in the national interest to attempt to channel new technologies in promising directions, we must ask who will perform the channeling function.

A central issue is the degree to which the Federal Government should accept responsibilities for direct action programs to stimulate economic growth.

Another issue is the degree to which the Government should accept responsibility for the active development of national resources. Logical arguments can be made that technological knowledge has become as important to regional and national economic health and growth as were natural resources in the past. Those favoring substantial Government involvement in programs to transfer technology argue that the precedent for such Federal involvement is in past and present Government programs to make rivers navigable, to aid in the exploration, use, and conservation of the Nation's mineral supplies, and other such programs.

A third question concerns regional balances. Arguments have been made in favor of Government support of technology transfer programs on the basis that such programs will tend to offset regional imbalances in technological sophistication resulting from the concentration of Federal R & D funding in a relatively few States.

A fourth question involves the issue of whether Government support of programs to transfer technology to the private sector would tend to work in favor of the marginal producer. The argument is that such Government involvement would interfere in the private economy because it would tend to bring to the marginal company a partial capability that must otherwise be gained through relatively high investment on the company's part.

A fifth debate centers about historical precedent for Government involvement in programs to promote scientific activity and technological achievement and to bring about the diffusion of science and technology throughout the economy.

One of the more forceful arguments for Government involvement in programs to channel new technologies into civilian applications rest on the dual points that (1) the Government is the generator of the vast bulk of new science and technology; and (2) a significant potential use for the new technology is in activities generally considered to be wholly or partially in the public sphere.

Another frequently heard argument is that the Federal Government should support vigorous efforts to transfer technology because it has a responsibility to the taxpayers to ensure the optimum return on the public investment in research and development. While the goal is desirable, the logic of the argument is debatable. If the secondary beneficiaries of the new technology can make optimum use of it without artificial stimulation, then Government Assistance would not seem warranted. History shows, however, that optimum use is not likely to occur naturally. And history proves quite emphatically that there will likely be a longer timelag between development of new technology and its civilian application via natural processes than would occur with some form of catalytic action.

Although the existence of some Federal responsibility in this area seems beyond doubt, there is a serious question of degree. Since two-thirds of all R & D work is supported by Federal funds, the Government clearly has a responsibility to make the results of this work available for the widest possible use.

RESEARCH IMPLICATIONS OF THE TRANSFER PROCESS

State of the Art

The diffusion of new technology into various uses and avenues of application can be viewed as a natural process. Thus, when we speak of research relative to the process of technology transfer, we refer to the quest for a better understanding of this admittedly complex natural system.

The ultimate objective of seeking through research a better understanding of how the natural technology transfer process operates is to identify promising mechanisms and technology transfer channels which might be utilized in accelerating the flow of new technology to business firms and in particular to those not active in the natural diffusion system.

The question of whether or not the search for a better understanding of technology transfer processes is in itself a worthwhile goal, will not be considered here. It was discussed briefly above and the assumption is made that the quest for understanding is justified.

The level of interest which has been generated in technology transfer at the national level is high. It is further indicated by the present degree of financial involvement on the part of the Federal Government, which even today remains considerable. Although small by comparison with R & D expenditures, allocation of Government resources directed toward technology transfer programs continues.

It is appropriate at this point to consider the nature of our present body of knowledge concerning technology transfer. Perhaps most important is the fact that efforts directed toward the transfer of new technology apparently seem to yield results more rapidly and in excess of those that might be expected from the natural diffusion process. The programs and activities of the National Aeronautics and Space Administration's (NASA) Technology Utilization Division are indicative of these directed efforts. The NASA Regional Dissemination Centers (RDC) have specific missions to aid and accelerate the flow of new technology resulting from Government R & D efforts to private industry.

The question of economics of these transfer efforts is by no means clear at this time. Measurement problems are difficult in terms of achieving cost-effectiveness comparisons. However, the information transfer mechanisms available from the RDC's involve quite modest costs to prospective users. Results gained from these transfer systems appear to be in excess of user costs.

The body of knowledge on technology transfer that has been assembled to date consists primarily of the recorded experiences of those who have carried out transfer activities. While these fragments of findings contribute to a better understanding, it is difficult, if not hazardous, to attempt to generalize from them.

A certain amount of pioneering and exploratory efforts seems appropriate in attempting to understand and analyze complex, natural systems. It appears that a stage of development has been reached in technology transfer such that two interrelated actions are indicated: (1) a careful assessment of findings to date, promising avenues identified, and the problems encountered specified, and (2) the formulation of a blueprint for future action.

The basic intent of this brief statement is to suggest the current need for pulling together our modest reservoir of technology transfer wisdom--and to order these findings against a framework which will be helpful in relating our findings as well as identifying questions and problems for future investigation.

Levels of Interest

The questions relevant to understanding the technology transfer process would seem to be different, depending on the level of investigation and the point of view taken. At least five levels can be identified:

1. The Public Policy or Aggregate Level. Here interest is centered in the entire system--the major elements involved and their interrelationships.

2. The Intermediary Level. This involves the level of interest reflected by the technology transfer intermediary such as the Regional Dissemination Center.

3. The Industry Level (Macro). This level refers to common interests with respect to a group of firms making up a particular industry.

4. Institutional Level. Institutions such as universities and not-for-profit research institutes fit into this level.

5. The Level of the Business Firm (Micro). This level of interest centers on the individual firm.

By breaking down interest in technology transfer into these five levels, we have the beginning of an analytical framework of potential use in ordering our present state of knowledge and in leading us to the identification of relevant questions.

For example, questions of relevance at the public policy level would very likely be different from those of the industrial firm seeking to improve the inflow of externally generated technology. Likewise, the technology transfer intermediary might focus on a third set of relevant questions. We might begin to structure our base of knowledge by using the admittedly crude frame of reference shown below:

	Current State of Knowledge	Appropriate Activities	Questions for Investigation
1. Public Policy	X	X	X
2. Intermediary	X	X	X
3. Industry	X	X	X
4. Institutional	X	X	X
5. Business Firm	X	X	X

This relatively simple framework: (1) provides for the partitioning of our current state of knowledge into five sections; (2) suggests that each of the five levels might involve different activities (and capabilities); and (3) indicates a group of relevant questions could be generated for each level. Of course, an effort to partition such a complex system into mutually exclusive sub-elements must consider the nature of the interrelationships among the levels involved. A certain amount of overlap is inherent. The important point is that we have a structure which recognizes different points of view.

Certain of the cells are blank at present. This might, in itself, suggest future emphasis. Activities appropriate at one level may well be inappropriate to another. The framework helps to make these important distinctions.

Some Relevant Questions

In conclusion, it might be useful to indicate the nature of the questions which seem relevant at different levels. Listed below are a few of the kinds of questions of interest at level 5, the Business Firm:

1. To what degree do business firms take an organized approach to setting up a network of external communications channels through which new technology can flow? What kinds of barriers exist?

2. Can a business firm organize internally to improve the inflow of externally generated technology?

3. Does the formulation, design, and implementation of intra-firm technology transfer mechanisms aid or hamper the process? If so, how?

4. Is the process of technology transfer so complex that organized mechanisms for accelerating the process tend to be less effective than the natural diffusion process?

5. Assuming that we can in fact improve the flow of externally generated technology into the firm, what are the major problems involved? Who should play the lead role in attempting to cope with the task?

In contrast, consider the nature of questions which seem relevant at level 1, the Public Policy or Aggregate Level. Here are a few that immediately occur:

1. Which institutions should play lead roles in technology transfer policy questions and actions--business firms, government, industry groups, professional organizations, universities, etc.?

2. Who should bear the costs of directed technology transfer efforts? (Contrast here the NASA self-supporting RDC concept with the Department of Commerce, State Technical Services Act programs while it was active.)

3. What sort of public policy coordination of technology transfer programs is appropriate at the national level?

4. To what degree is there a willingness and desire on the part of industrial firms to have the federal government actively pursue directed technology transfer efforts?

5. In what respects is the natural process of technology transfer deficient?

These are only a few of the many questions that might be hammered out at the various levels of interest. The questions indicated are, at best, only suggestive. The important point that hopefully has come out of this discussion is the need for pulling together our fragments of existing knowledge into a logical, yet flexible, frame of reference which would lead to: (1) identifying appropriate activities and capabilities at each level and (2) raising relevant questions for investigation at each level.

THE FUNCTION OF ARAC

Several inter-related implications of the technology transfer concept have been discussed above. Some of the arguments made and questions asked could easily constitute the subject matter of many volumes, but for present purposes, enough has been said. The activities and operations of ARAC are related to many of the topics mentioned in this chapter and to all the other aspects of the technology transfer concept discussed throughout the entire report. It is hoped that this report will serve to delineate these relationships.

The activities and operations of ARAC to date have been varied and interesting, typically straddling many disciplines. It is anticipated that the role of ARAC will continue to be an important element in the evolution of the technology transfer concept. There are a number of specific functions and objectives which are within the realm of capabilities for ARAC, and which would constitute significant contributions to this concept for ARAC and similar types of operations. These functions and objectives for ARAC are:

1. To continue to operate a pilot technology transfer action program via sale of information products and services.

2. To operate the pilot transfer program mentioned above on a break-even basis with revenues generated.

3. To continue to do research (as resources permit) aimed at obtaining a better understanding of the transfer process.

4. To continue studies aimed at obtaining a better understanding of the transfer process as it applies to small business.

5. To continue to evaluate (and incorporate when justified) new information resources.

6. To seek economies and improvements in the method of provision of information services to industrial firms.

7. To continue to document specific transfer case history examples.

8. To develop information products and resources which can be used toward the solution of today's social and urban problems.

9. To allow use of the ARAC operation as a laboratory for "outsiders" seeking to do research on the transfer process.

10. To publicize and promote the transfer concept and the potentials attendant to effective utilization of information.

11. To serve as one of the few places where persons can be trained to take responsible positions in the newly created information industries.

12. To continue effort aimed at causing the transfer concept to be introduced into the curriculum in a wide variety of disciplines.

13. To continue to be an important resource to the host university.

14. To seek new and better methods of educating the general public toward the benefits to effective utilization of information.

15. To continue to seek meaningful methods of measuring the impact of the functions listed above.

APPENDIX A

DESCRIPTION OF ARAC SERVICES

RETROSPECTIVE SEARCH SERVICE (RSS)

Definition

The Retrospective Search Service (RSS) provides a means of searching the government and non-government generated literature on a given, well-defined subject. The government literature is produced by government contracted projects in industry, universities, and other institutions, as well as in the various government laboratories and research centers. The non-government sources include the most significant technical information files available in the world. Very often the names of specialists working at various sites are uncovered in performing a search and these specialists have shown a willingness to be contacted directly for further supplementary information on a given subject when the nature of the topic does not involve proprietary information. (Please see Figure 3.1 for an illustration of ARAC resources.)

In its first six years, ARAC processed over 4,000 searches. These covered subjects in practically every area of technology and ranged from questions on basic science to manufacturing techniques to management and marketing. Some have been broad state-of-the-art inquiries and others have been very specific problems. A selected list of Retrospective Search titles is shown in Table A-1.

Company Procedure

The mechanism of the Retrospective Search Service is shown in Figure A-1. A retrospective search is initiated by a user's request. The first step in requesting a search usually is the completion of the search request form, Form 451, which is mailed to ARAC. Figure A-2 shows a completed form. However, many users prefer to telephone their request, especially when urgent processing is required.

The information required by ARAC in either case is a concise statement of the question or problem and some background information which will aid the searcher in processing the inquiry. Additional information could include possible fringe areas of interest, types of information not desired, limiting dates, and previous sources of information consulted.

A telephone call by the ARAC staff member to whom the search is assigned is made during the preliminary phase of a search to determine that there is a clear understanding on the part of the staff member as to the nature of the search.

The most satisfactory results are obtained when a company regards the ARAC staff member as a temporary member of its own staff for the purposes of completing the search.

Searches are normally completed within a period of two weeks after receipt. The decision as to which resources should be searched in quest of relevant information is normally left to the ARAC staff specialist since he is both familiar with the contents of the various files and now has a clear understanding of the problem, thus creating ideal conditions for

Table A-1 Selected List of Retrospective Search Titles

Failure Theories
Energy Absorbing Devices
Methods of Training Technical People
Stereoscopic Display Systems
Human Environmental Effects
Ripper Design
Percussive Welding
Apparatus for Learning Research
Methods of Monitoring Sewage Flow
R & D Decision Making
Moisture Detection in Wood Veneer
Underwater Sound Detection and Propagation
Properties of Radon and Xenon
Power Screws
Non-Stick O-Ring Seals
Results of AF Contract AF-33/615/3747
Survey of Fluid Amplifiers
Non-Destructive Testing
Synoptic Vesicles
Fiber Optics
Plastic-to-Metal Bonding Techniques
Dental Health Survey
Reconnaissance
Numerical Analysis of Heat Transfer
Design of Permanent Magnets
Relaxation Phenomena
Techniques of Information Retrieval
Plant and Laboratory Location Theory
Flame Retardant Paint
Pyrolysis of PVC
Biomedical Ultrasonics
Zero-Gravity Fuel Measurement
Artificial Heart Physiology

Figure A.1 ARAC Retrospective Search Flow Chart

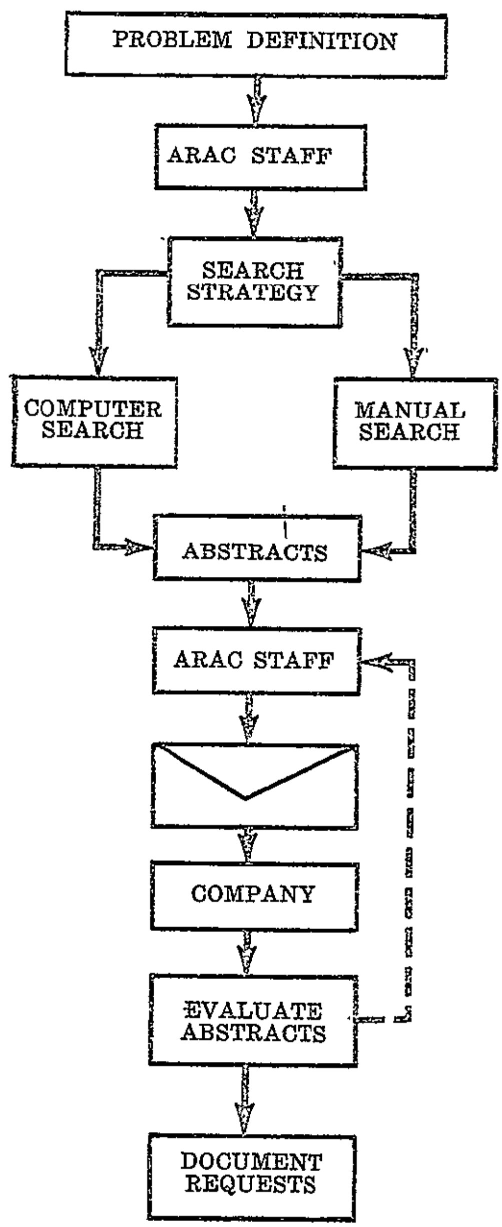


Figure A.2 ARAC Retrospective Search Request Form

RETROSPECTIVE SEARCH REQUEST

COMPANY NAME: The XYZ Corporation

DATE OF REQUEST: 3/1/67

MAIL RESULTS TO:

DATE RESULTS NEEDED: 3/15/67

NAME: Miss Betty Watson, Librarian

ADDRESS: Consumer Products Division

The XYZ Corporation

CITY: Hannibal

STATE: Missouri ZIP CODE: 61602

UNLESS OTHERWISE REQUESTED, ARAC'S INITIAL REPLY WILL BE MAILED FIRST CLASS WITHIN 14 DAYS AFTER RECEIPT OF THIS FORM AT ARAC. QUESTIONS MAY BE PHONED TO 812-337-8884. TELEPHONE REPLIES CAN BE MADE.

INDIVIDUAL TO TELEPHONE FOR DISCUSSION OF QUESTION: M. H. G. Weir, Project Engineer
TELEPHONE NO.: 314-624-3500, Ext. 248

TITLE OF QUESTION: Weld Inspection

DEFINITION OF QUESTION OR PROBLEM:
(Use additional sheets, sketches, or attached material as necessary.)

We desire to locate a means or develop the capability to inspect seam welds on concentric seam welded metal tubing which precludes the necessity of placing a fluid in the pipe.

The present means of inspection is to place water in the pipe under pressure. This method is time consuming and is not readily performed in the field.

DO YOU KNOW OF LOCATIONS OR PERSONS WITHIN THE GOVERNMENT DOING WORK WHICH MAY BE RELEVANT TO YOUR QUESTION?

Redstone Arsenal, Alabama. Have heard that they have an evaluation program for methods of non-destructive testing of metals.

OTHER SOURCES BEING CONSULTED:

General Library Search

ARAC FORM #451 #
January 13, 1967

AEROSPACE RESEARCH
APPLICATIONS CENTER
INDIANA UNIVERSITY FOUNDATIONS
BLOOMINGTON, INDIANA 47401

locating the relevant information. In some cases, personnel in ARAC user firms may specifically request that certain sources be queried. Naturally, it is preferable to search only machine-readable sources in conducting a search because of the reduced amount of time required. However, if this does not yield a satisfactory result, other means are used depending upon the nature of the problem. The judgement and experience of the ARAC staff specialist determines to a large extent the scope and results of a search.

The output of a search is a set of relevant abstracts, critically screened by the ARAC staff member, and sent to the company requester. He then reviews the abstracts and may order full documents of any reports which may be of particular interest to him. The user of the services then completes and returns an evaluation form to the ARAC staff member. This enables ARAC to evaluate its techniques and the effectiveness of its services.

SELECTIVE DISSEMINATION SERVICE

Definition

The semimonthly dissemination service provides a means of maintaining an awareness of the current literature in a specific area. With nearly 15,000 new reports being added to the ARAC information warehouse each month, it is quite evident why such a service fills a real need for the practicing engineer or scientist. Effective utilization of this service is to a large degree dependent upon the extent that it is a joint activity between a company professional and an ARAC staff member.

Two types of current awareness services have been developed. One involves Standard Interest Profiles (SIP), and the other involves Customized Interest Profiles (CIP). The availability of these two types of interest profiles provides the user with a greater degree of flexibility in satisfying his current awareness information needs within his budget. Figure A-3 depicts the operation of these two types of selective dissemination services.

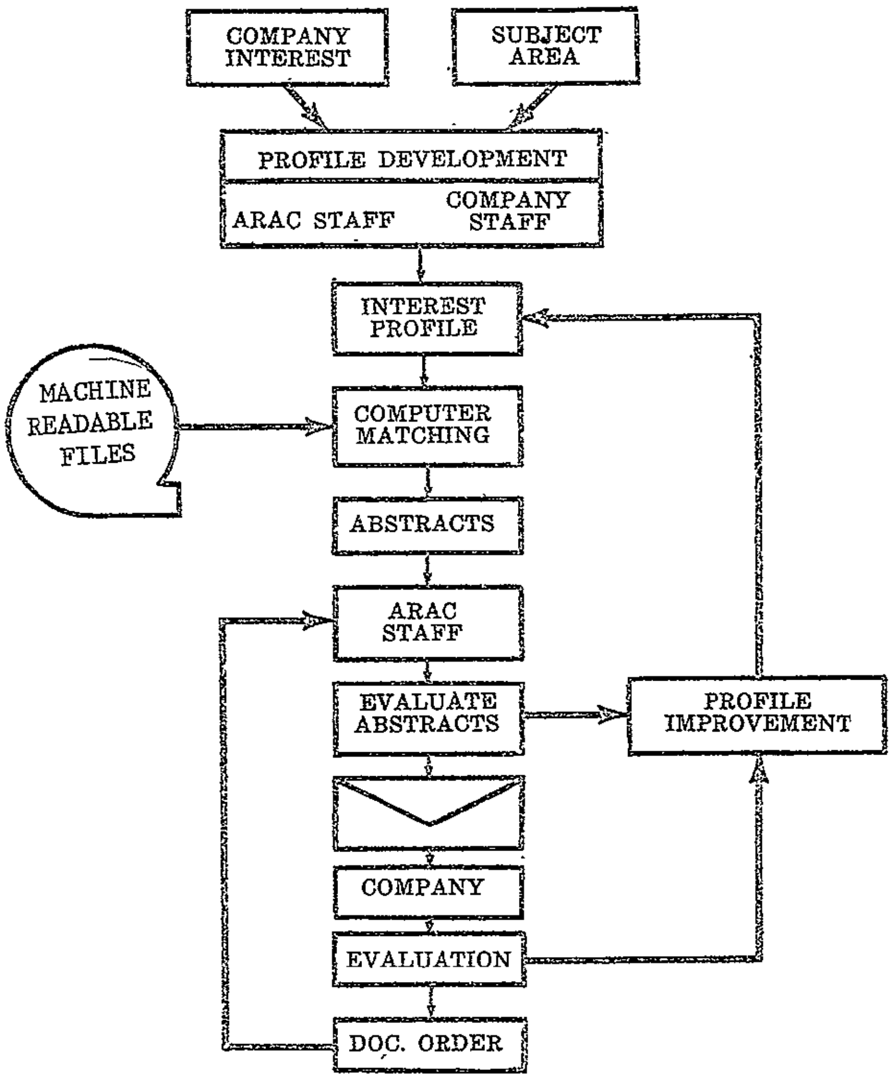
Custom Interest Profiles (CIP) reflect a specific user's particular work interests in a given area and are sent only to that user. There is the distinct advantage of direct feedback to, and dialogue with the ARAC staff member servicing the profile. This results in the improvement or alteration of a profile dependent upon the user's changing needs. The cost of a CIP varies with the number of abstracts selected by the computer.

Standard Interest Profiles (SIP) reflect general areas of user interest in a subject. The same output is sent to anyone subscribing to a given SIP. They cannot be changed to satisfy the desires of any given user; any changes will be made by ARAC based upon periodic feedback from all users of a particular SIP, but not necessarily that of any individual user.

Company Procedure - Customized Interest Profile (CIP)

A subject for a customized interest profile (CIP) should be well-defined. The procedure for a user to develop such a profile is to first

Figure A.3 Interest Profile Flow Chart



complete ARAC Form 453. An illustration of a completed form may be seen in Figure A-4.

It may be seen that a definition contains both main descriptors and related terms and a verbal description of the main areas of interest. Experience has shown that it is better for a user to state his interests in terms of relevant technology rather than in terms of products or processes. For example, it might be apt to describe bearing manufacture in the areas of metal bearing properties, metal cutting, welding, lubrication, and galling properties of various metals. It is also appropriate to itemize subjects that are specifically not wanted. This enables the ARAC staff engineer to negate certain terms in the search strategy.

Each customized interest profile is evaluated shortly after the user receives several issues. This is usually done by telephone and is a cooperative effort between the profile recipient in the company and the ARAC staff engineer. After evaluating the relevancy and getting the comments of the recipient, the staff member is able to adjust his search strategy so that more relevant and pertinent literature references will be cited.

A CIP mailing consists of a set of abstracts and an evaluation form. The evaluation cards provide a continuing evaluation of a profile. This is one means by which the ARAC staff engineer may conduct a continuous monitoring of a customized interest profile. Another means of evaluating profile effectiveness is for the ARAC staff member to call the recipient occasionally and discuss the profile with him. A profile may be revised at any time as primary technical interests of the company change.

Company Procedure - Standard Interest Profiles (SIP)

A large number of Standard Interest Profiles have been developed covering a wide range of technological areas. A complete list of titles of subject areas may be found in Appendix C of this report. The logic behind development of Standard Interest Profiles may be found in the section of this report describing ARAC contributions to information science. The current ARAC Services Catalog, available upon request, contains a complete description of each topic area covered. These profiles are useful in two respects. First, this is a less expensive means of maintaining current awareness in a given field. Second, the descriptions of technical areas covered should be very suggestive to recipients who are attempting to define their interests in customized profiles, but are not yet familiar with the subject areas in which ARAC has useful information.

The profile description outlines material from the ARAC information store which is known from experience to be of industrial interest. However, this does not mean that information is not available in other areas. Many customized profiles are in operation in subject areas not covered by the standard profiles.

Two criteria have been met in the development of each SIP. First, the subject areas selected have been found to be of interest to a number of people in industry. In some cases ARAC has detected remarkable

AEROSPACE RESEARCH APPLICATIONS CENTER

Indiana University Foundation
Bloomington, Indiana 47401

SELECTIVE DISSEMINATION SERVICE
INTEREST PROFILE FORM

NAME Mr. J. T. Williams TELEPHONE 339-2144

ADDRESS The XYZ Company DATE March 15, 1967

1700 West 10th Street

Oconomowoc, Wisconsin

Describe the general aims of this center, the products involved, the production methods, and the current and planned research.

Semiconductor Department

This department is involved with every facet of semiconductor manufacturing. Our interests range from crystal growth through final product marketing.

Our department manufactures all types of solid state components for both industrial and consumer markets. These products include complete lines of silicon diodes, transistors and AC control devices. Our department is presently developing a line of integrated circuits employing, we believe, the most advanced techniques in the microelectronic field.

This department would have an interest only in manufacturing-oriented literature. Circuit applications, new product development and quality control are handled by other departments within the corporation. New ideas and concepts must be economical to initiate and maintain, and, in addition, applicable to high volume, automated production.

Our resources include an excellent company library receiving all popular domestic and foreign trade and technical periodicals. The library also is equipped with microfilm reader-printer facilities.

Our engineering staff encompasses all major technical disciplines, including several specialists in solid state physics.

The following pages should be filled in with terms appropriate to your interest center. Synonyms should be included and each term should be amplified in the manner indicated. In addition, each term which describes a new or unusual product or concept should be defined, and if possible, a reference concerning it should be cited. Avoid broad terms such as "mathematics." If there are more terms applicable to the various aspects of your center than there is space provided, please use additional sheets incorporating the same format. If possible, please send a catalogue when you return the form.

ARAC FORM 453 (Page 1 of 2)
(2-67)

NOT REPRODUCIBLE

MAIN DESCRIPTORS and RELATED TERMS	In the space below answer the following questions for each term. Any pertinent data not covered by the questions should also be included. To what use do you put this? What related subjects do you wish explored? What problems are associated with this?
CRYSTAL & JUNCTION TECHNOLOGY Growth Doping	We grow approximately 75% of our own crystal requirements. We would be interested in improved growing techniques which would insure and/or improve crystal quality. Most of our junctions are made with diffusion techniques. In both crystal growth and junction formation, atmosphere and temperature control are critical and of primary concern. We also produce point-contact and alloyed junction devices.
DEVICES Transistor Diode SCR Microcircuit	In addition to a standard line of transistors we manufacture devices with the following characteristics: unijunction, field effect, mesa, planar and epitaxiol. We produce both germanium and silicon diodes with current ratings up to 500 amperes. Included in our line are: zener diodes, mixer diodes, tunnel diodes, variable capacitance diodes, avalanche diodes and photodiodes. We manufacture a complete line of conventional silicon controlled rectifiers. Our interests in the microelectronics area is quite broad at this time. We are presently in the advanced planning and prototype stage and all relevant information would be helpful.
MANUFACTURING PROCESSES Surface Preparation Cutting Bonding	Before being used in a device, crystals and junctions must be prepared employing some of the following techniques: cutting (ultrasonic), slicing, dicing, etching, lapping, cleaning, passivation. Conductors must be attached by either soldering, welding, or brazing. In many of these processes controlled atmospheres and temperatures are required. We are presently employing photolithography in the manufacturing of several devices.

Continue in this manner using all applicable descriptors and terms.

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(2-67)

Figure A.4 ARAC Customized Interest Profile (CIP) Form commonality in the interests of people in different industries. For example, there are very few manufacturers who do not have someone interested in developments in bearings and lubricants. Nearly everyone uses them.

A second criterion is that ARAC should be able to consistently provide reports in the subject areas outlined. This means that the Center expects to be able to provide five to fifty abstracts of reports on the subject every two weeks. Because of this report quantity criterion, some of the Standard Interest Profiles will cite reports in a broader subject area than that in which some recipients will be interested. Conversely, some recipients may find that two or three standard interest profiles are required to cover the full range of their interests.

However, if a user's interests are such that no selection of a combination of standard interest profiles is adequate, the outline of SIP topics may help to formulate the user's thinking in requesting a customized interest profile (CIP). ARAC will provide assistance to a company in assessing its needs and interests; this would include a selection of standard interest profiles and the construction of customized interest profiles to fully cover company needs.

Since ARAC has designed the Standard Interest Profiles with users in mind, there have been no attempts to make the subject content of each SIP independent of all others. Any given report may be cited in several different SIP profiles if the subject matter of the report is appropriate. For example, it is possible to receive abstracts on structural adhesives from either the SIP on Materials Joining or the one on Reinforced Plastics.

To acquaint the reader with the nature of coverage in a given field, brief descriptions of the content for three ARAC Standard Interest Profiles are listed below.

SIP-04 PHYSICAL METALLURGY

Areas covered by this profile include crystalline structure of metals, solid solutions, precipitates, diffusion, atomic structure, dislocations, cleavage, hardening and phase transformations. Some articles will be focused on methods of analysis such as electron microscopy, X-ray diffraction, fractography, microscopy, etchants and sample preparation. In order to make the profile more useful to non-aerospace users, a large number of reports dealing with titanium and with radiation effects on metals are suppressed.

SIP-27 LOGIC CIRCUITS

Electronic computation and control devices are very predominant in NASA-developed technology. Because of this, there are articles and reports on logic circuits which are often pertinent to industrial work on similar devices for non-aerospace applications.

Both theory and design are considered in reports. Specifically included are gates, multipliers, adders, bi-stable circuits, trigger circuits, multi-vibrators, counters, clocks, and thin film or solid state components used. Applications are frequently concerned with computers, but the orientation of the profile is not exclusively directed at computer hardware so that a great many of the cited applications are for miscellaneous control or monitoring systems, and there should therefore be a broad interest in it.

SIP-39 OPERATIONS RESEARCH (Management)

The focus of the profile is concerned with the area of quantitative analysis as defined by a number of established OR techniques such as linear and non-linear programming, queuing theory, Markov processes, and dynamic programming. It is designed to service the specialist in operations research, quantitative analysis, and management science.

In some of the reports methodology will be discussed in terms of model formulation or construction. Possible topics include probability theory, statistics, analysis of variance, experimental design, special optimization techniques, calculus of variations, and decision theory.

These examples are representative of the wide range of subjects covered by the many Standard Interest Profiles that have been developed. Additional SIP profiles are constantly under development and ARAC members are notified when they become available.

Abstracts are sent in a form suitable for inserting in a three-ring binder for users interested in keeping them for later reference.

INDUSTRIAL APPLICATIONS SERVICE

Definition

The Industrial Applications Service is designed to bring to the attention of ARAC users those reports and innovations which may be of potentially high interest to industry. This is one of ARAC's "push" services mentioned in Chapter III, and is designed to provide idea-generating information rather than to respond to company requests (as do the "pull" services such as RSS and SDS). Currently, the IAS packet is mailed weekly to several hundred company mailing points throughout the country. An IAS weekly mailing is presently composed of eight abstracts of ARAC-selected reports and fourteen NASA Tech Briefs.

Staff members in the various disciplines select reports for IAS use which have high potential for industrial application. Several criteria are used for selecting these reports. First, they must be well written; second, they must be sufficiently broad to adequately cover a given subject. A broad range of technical areas are covered by these reports. It is felt that this type of coverage will give members a quick glance at developments in different areas and that there will be periodic appeal for the majority of members, who are found in many different industries. The reports selected include those covered by SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS, U. S. GOVERNMENT RESEARCH AND DEVELOPMENT REPORTS, and NASA special reports and contractor reports. Important innovative reports from non-government sources are also included on occasion.

Tech Briefs are one or two page descriptions of innovations developed at various NASA Centers throughout the country, and by NASA contractors. They are reported by staff engineers and scientists at the NASA Centers, or under contract, and also cover a wide range of technology. ARAC will provide backup or supplementary information on Tech Briefs, or may serve as liaison between the company man and the government scientist or engineer who wrote the Tech Brief. Backup information may be in the form of verbal communication or printed reports. Acting in a liaison capacity, ARAC will arrange a telephone contact between the company man and his government counterpart.

Indices of all Industrial Application Reports and Tech Briefs issued since the beginning of the service have been prepared and may be obtained from ARAC.

Company Procedure

Included with the IAS weekly mailing of abstracts is a form for ordering full reports. A certain number of inventory copies are made up beforehand based on demand analysis, and as such requests for full reports are filled quickly.

Supplementary information on the Tech Briefs is also available from ARAC upon request and may consist of full reports on a given subject or telephone contacts arranged with government personnel involved in the innovation whenever this can be accomplished.

MARKETING INFORMATION SERVICE

Definition

The purposes of the Marketing Information Service, another ARAC "push" service, are:

- To provide company marketing people with information on the latest methods and techniques for increasing the effectiveness of marketing programs.

- To provide company marketing people with specific problem-solving information.

- To aid member companies identify new marketing opportunities.

1. New Dimensions in Marketing Technology: This is the title of a monthly package of approximately ten abstracts of articles designed to provide marketing managers with information on new developments in marketing management, marketing research, marketing analysis, etc. The articles abstracted in "New Dimensions" cover a wide spectrum of marketing as well as developments in other areas--Operations Research, Communication,

Sociology, etc.--which are making significant contributions to marketing management.

The specific aim of "New Dimensions" is to acquaint subscribers of this service with new techniques and methods in the marketing field. To this end, the ARAC staff peruse approximately seventy journals, books, and proceedings in an effort to pinpoint articles which would be of interest to marketing personnel. The journals searched are from both the marketing and non-marketing disciplines containing the kind of information useful for understanding and meeting the demands of tomorrow's markets.

Typical of the journals which are regularly searched are the Journal of Marketing, Journal of Marketing Research, Journal of Advertising Research, Harvard Business Review, Business Horizons, Management Science, Journal of Operations Research, American Journal of Sociology, International Science and Technology, and various law journals.

2. Marketing Information: This service is essentially designed to encourage marketing people in each member company to utilize the information capabilities of ARAC by submitting marketing problems for analysis by ARAC's business and technical staff. The initial output of ARAC in this service is a set of abstracts as in the Retrospective Search Service.

Marketing questions are considered a search in the Retrospective Search Service. Requests for specific information will be answered by a manual or computer search of the scientific and technical information sources avaialble to ARAC. These questions may be for market facts and data, the identification of market opportunities for existing technology and products, the identification of firms active in specific technical and product areas, market projections, and various other questions.

3. Marketing Consulting Liaison Service: ARAC provides liaison service to member companies in arranging appropriate consulting services in marketing as in other areas.

Company Procedure

The necessary company action to initiate the various segments of the Marketing Information Service includes:

"New Dimensions in Marketing Technology" (Monthly Abstract Service): Provide ARAC a listing of company marketing personnel who desire to receive the monthly abstract mailings. Included with the monthly abstract mailing are forms for ordering the complete article. The reprints of the article are normally delivered within two weeks of the order date.

Marketing Information: Any nature of communication--personal, phone, or mail advising ARAC of the nature of the question submitted as a retrospective search request.

COMPUTER INFORMATION SERVICE

Definition

The Computer Information Service (CIS) serves a twofold purpose. Primarily the CIS makes available to our member companies those computer programs which are generated in the course of NASA R & D. Secondly, the CIS attempts to keep a member company abreast of developments in the computer world. This service is another of the "push" services provided by ARAC.

To accomplish these goals the CIS announces the availability of approximately five new computer programs for various purposes per month. Information concerning programming language, operating system and an abstract explaining what each program does, constitute the program announcements. In addition to these announcements, the output of a Standard Interest Profile (SIP) of computer-related reports is also provided. The orientation of this profile is toward new and novel techniques, ideas, innovations, etc., in the computer field.

The program announcements and the abstracts from the Standard Interest Profile constitute a complete CIS announcement (mailing) each month.

Company Procedure

In order for a company to be added to the mailing list for the CIS, a request to this effect should be made to the ARAC Director of Operations. The person or persons who should begin receiving the mailing should be indicated at the time of the request. An indexed catalog listing all computer programs available in the ARAC library of programs is available upon request.

ARAC DOCUMENT AND REPORT SERVICE

Complete reports cited by all abstracts announced may be ordered through ARAC by completing the form accompanying the announcement. Documents may be obtained as hard (paper) copy or as microfiche if the report is available in that form. Microfiche form requires the use of a reader. Readers are available from a number of companies and their cost is in the range of \$150-\$200. A standard microfiche card measures 4" x 6" and contains up to sixty frames of document pages. The reader enlarges a microfiche frame of a document page by approximately thirteen to sixteen times (essentially back to original size) and the enlarged image may be viewed on a screen. Equipment exists which also makes a permanent copy of the enlarged image.

There exists several different classifications of documents available from ARAC depending primarily on how the document copy is produced.

ARAC has a collection of nearly 600,000 reports on microfiche, copies of reports in this category are made on photo blow-back equipment at a nominal per page charge and sent within forty-eight hours after receipt of the order. ARAC can also supply these reports in microfiche form by making duplicate microfiche. These requests are also filled on a forty-eight hour basis on a per sheet of film used basis.

Another category of reports are those of which ARAC makes mass printings, usually via offset press. Orders for these reports are filled immediately and charges are made on a cost basis.

In many cases ARAC receives orders for reports which are not available to the Center locally. When this occurs, ARAC obtains the report from the outside source and forwards it to the requestor for cost of the report to ARAC plus a small handling charge.

APPENDIX B

LIST OF NASA REGIONAL DISSEMINATION CENTERS

NASA REGIONAL DISSEMINATION CENTERS

Aerospace Research Applications Center
Indiana University Foundation
Indiana Memorial Union
Indiana University
Bloomington, Indiana 47401

Knowledge Availability Systems Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

New England Research Application Center
The University of Connecticut
Storrs, Connecticut 06268

North Carolina Science & Technology Research Center
P. O. Box 12235
Research Triangle Park
North Carolina 27709

Technology Application Center
The University of New Mexico
P. O. Box 181
Albuquerque, New Mexico 87106

Western Research Application Center
University of Southern California
Los Angeles, California 90007

APPENDIX C

COMPLETE LIST OF ARAC STANDARD INTEREST PROFILES

TITLE LIST OF STANDARD INTEREST PROFILES

SIP-02	Crystal Growth
SIP-03	Carbon and Graphite
SIP-04	Physical Metallurgy
SIP-05	Powder Metallurgy
SIP-06	High Temperature Materials
SIP-07	Materials Joining Technology
SIP-08	Material Forming and Machining
SIP-09	Microanalysis and Properties of Engineering Materials
SIP-10	Non-Destructive Testing
SIP-11	Corrosion and Protective Coatings
SIP-12	Nuclear Power Reactors
SIP-13	Bearings and Lubrication
SIP-14	Aerial Survey Techniques
SIP-15	Fluid Flow
SIP-16	Fuels and Combustion for Air Breathing Engines
SIP-17	Air and Water Pollution
SIP-18	Analytical Chemistry
SIP-19	Reinforced Plastics and Composite Materials
SIP-20	Polymer Technology
SIP-21	Temperature Measurement
SIP-22	Vacuum Technology
SIP-23	Fluidics
SIP-24	Laser Applications
SIP-25	Laser Research
SIP-26	Cryogenics and Superconductors
SIP-27	Logic Circuits
SIP-28	Infrared Instrumentation
SIP-29	Photography
SIP-30	Display Systems
SIP-31	Data Transmission
SIP-33	Recording Systems
SIP-34	Semiconductor Devices and Microcircuit Fabrication
SIP-35	Microwave Systems
SIP-36	Radio Antennas, Transmission, and Propagation
SIP-37	Radio Communications Equipment
SIP-38	Reliability
SIP-39	Operations Research
SIP-41	Personnel Management and Behavioral Science
SIP-42	Stress Physiology
SIP-43	Biomedical Technology
SIP-44	Radiobiology
SIP-45	Turbine Technology
SIP-46	Information Science
SIP-47	Glass and Ceramics
SIP-48	Optics
SIP-49	Control Systems Analysis
SIP-50	Magnetohydrodynamics
SIP-52	Sensory Devices for Instrumentation
SIP-59	Industrial Safety, Fire Protection, and Radiation Protection

SIP-60	Space-Age Energy Sources
SIP-63	Industrial Mathematics
SIP-68	Heat Transfer
SIP-69	Dielectric Materials and Electrical Insulation
SIP-70	Holography
SIP-71	Human Factors Engineering
SIP-73	Geophysics, Geology, and Oceanography
SIP-75	Structural Analysis and Design
SIP-76	Psychophysiology
SIP-77	Neurochemistry and Biochemistry
SIP-103	Diesel Engines
SIP-105	Powder Metallurgy
SIP-108	Material Forming and Machining
SIP-110	Non-Destructive Testing
SIP-111	Corrosion
SIP-112	Liquid Fuels
SIP-113	Bearings and Lubrication
SIP-114	Land Surveying
SIP-115	Paints and Coatings
SIP-116	High Temperature Polymers
SIP-117	Air Pollution, Smoke Abatement, and Dust Control
SIP-118	Petroleum Exploration and Production
SIP-119	Pumps, Compressors, Pipe, Valves, and Fittings
SIP-120	Fire Resistant Polymers
SIP-123	Refrigeration
SIP-125	Water Treatment and Distribution
SIP-126	Cryogenics and Superconductors
SIP-127	Logic Circuits
SIP-130	Display Systems
SIP-132	Illumination Engineering
SIP-133	Recording Systems
SIP-134	Semiconductor Devices and Microcircuit Fabrication
SIP-135	Microwave Systems
SIP-136	Radio Antennas, Transmission, and Propagation
SIP-137	Radio Communications Equipment
SIP-138	Reliability and Quality Control
SIP-139	Operations Research
SIP-143	Biomedical Technology
SIP-144	Water Resources and Pollution Control
SIP-147	Glass and Ceramics
SIP-148	Optics
SIP-149	Control Systems Analysis
SIP-151	Solders, Soldering, and Electronic Assembly
SIP-152	Sensory Devices for Instrumentation
SIP-153	Chemical Process Engineering
SIP-154	Plating and Coating with Metals
SIP-155	Hydraulic Control and Transmission
SIP-157	Testing of Metals
SIP-158	Testing of Non-Metallic Materials
SIP-159	Industrial Safety and Fire Protection
SIP-161	Sanitary Engineering and Waste Disposal
SIP-162	Steam Turbines and Machinery

SIP-164 Thermodynamics
SIP-166 Heating, Ventilating, and Air Conditioning
SIP-167 Boilers, Pressure Vessels, and Heat Transfer Equipment
SIP-169 Dielectric Materials and Electrical Insulation
SIP-172 Natural and Synthetic Textiles
SIP-173 Geology, Geophysical Exploration, and Mineral Resources
SIP-174 Mechanical Power Transmission
SIP-176 Materials Handling and Storage
SIP-178 Polyvinyl Chloride
SIP-179 Film and Adhesives for Packaging
SIP-180 Polyolefins
SIP-181 Plastics Molding
SIP-182 Adhesives
SIP-183 Foamed Polymers
SIP-184 Reinforced Plastics and Composite Materials
SIP-185 Machining and Cold Forming of Plastics
SIP-187 Paper, Pulp, and Cellulose Products
SIP-188 Polystyrene and ABS
SIP-189 Epoxy Polymers
SIP-190 Electrical Power Generation
SIP-191 Electrical Power Transmission
SIP-192 Internal Combustion Engines
SIP-193 Electrical Machinery
SIP-194 Measurement and Measuring Instruments
SIP-195 Fluid Flow
SIP-196 Oceanography
SIP-197 Surface Transportation
SIP-198 Welding and Cutting of Metals
SIP-199 Petroleum Transportation, Refining, and Storage

CATEGORY LIST OF STANDARD INTEREST PROFILES

Polymers and Plastics

SIP-19	Reinforced Plastics and Composite Materials
SIP-20	Polymer Technology
SIP-115	Paints and Coatings
SIP-116	High Temperature Polymers
SIP-120	Fire Resistant Polymers
SIP-158	Testing of Non-Metallic Materials
SIP-178	Polyvinyl Chloride
SIP-179	Film and Adhesives for Packaging
SIP-180	Polyolefins
SIP-181	Plastics Molding
SIP-182	Adhesives
SIP-183	Foamed Polymers
SIP-184	Reinforced Plastics and Composite Materials
SIP-185	Machining & Cold Forming of Plastics
SIP-188	Polystyrene and ABS
SIP-189	Epoxy Polymers

Chemical Engineering and Chemistry

SIP-02	Crystal Growth
SIP-15	Fluid Flow
SIP-16	Fuels and Combustion for Air Breathing Engines
SIP-17	Air and Water Pollution
SIP-18	Analytical Chemistry
SIP-68	Heat Transfer
SIP-112	Liquid Fuels
SIP-117	Air Pollution, Smoke Abatement, and Dust Control
SIP-119	Pumps, Compressors, Pipe, Valves and Fittings
SIP-123	Refrigeration
SIP-125	Water Treatment and Distribution
SIP-144	Water Resources and Pollution Control
SIP-153	Chemical Process Engineering
SIP-154	Plating and Coating with Metals
SIP-161	Sanitary Engineering and Waste Disposal
SIP-164	Thermodynamics
SIP-167	Boilers, Pressure Vessels, and Heat Transfer Equipment
SIP-187	Paper, Pulp, and Cellulose Products
SIP-195	Fluid Flow
SIP-199	Petroleum Transportation, Refining, and Storage

Computer & Information Sciences

SIP-23	Fluidics
SIP-27	Logic Circuits
SIP-29	Photography
SIP-40	Computer Information Service
SIP-46	Information Science
SIP-127	Logic Circuits

Earth Sciences

SIP-14	Aerial Survey Techniques
SIP-17	Air and Water Pollution
SIP-73	Geophysics, Geology and Oceanography
SIP-114	Land Surveying
SIP-118	Petroleum Exploration and Production
SIP-144	Water Resources and Pollution Control
SIP-173	Geology, Geophysical Exploration, and Mineral Resources
SIP-196	Oceanography

Electronics & Electrical Engineering

SIP-10	Non-Destructive Testing
SIP-27	Logic Circuits
SIP-30	Display Systems
SIP-31	Data Transmission
SIP-33	Recording Systems
SIP-34	Semiconductor Devices and Microcircuit Fabrication
SIP-36	Microwave Systems
SIP-36	Radio Antennas, Transmission, and Propagation
SIP-37	Radio Communications Equipment
SIP-38	Reliability
SIP-49	Control Systems Analysis
SIP-69	Dielectric Materials and Electrical Insulation
SIP-70	Holography
SIP-110	Non-Destructive Testing
SIP-127	Logic Circuits
SIP-130	Display Systems
SIP-132	Illumination Engineering
SIP-133	Recording Systems
SIP-134	Semiconductor Devices and Microcircuit Fabrication
SIP-135	Microwave Systems
SIP-136	Radio Antennas, Transmission, and Propagation
SIP-137	Radio Communications Equipment
SIP-149	Control Systems Analysis
SIP-151	Solders, Soldering and Microcircuit Fabrication
SIP-169	Dielectric Materials and Electrical Insulation
SIP-190	Electrical Power Generation
SIP-191	Electrical Power Transmission
SIP-193	Electrical Machinery

Energy Sources

SIP-12	Nuclear Power Reactors
SIP-50	Magnetohydrodynamics
SIP-60	Space-Age Energy Sources
SIP-103	Diesel Engines
SIP-190	Electrical Power Generation
SIP-192	Internal Combustion Engines

Life Sciences

SIP-42	Stress Physiology
SIP-43	Biomedical Technology
SIP-44	Radiobiology
SIP-76	Psychophysiology
SIP-77	Neurochemistry and Biochemistry
SIP-143	Biomedical Technology
SIP-161	Sanitary Engineering and Waste Disposal

Management

SIP-38	Reliability
SIP-39	Operations Research
SIP-41	Personnel Management and Behavioral Science
SIP-49	Industrial Safety, Fire Protection, and Radiation Protection
SIP-63	Industrial Mathematics
SIP-71	Human Factors Engineering
SIP-74	Marketing Information Service
SIP-138	Reliability and Quality Control
SIP-139	Operations Research
SIP-159	Industrial Safety and Fire Protection
SIP-176	Materials Handling and Storage
SIP-197	Surface Transportation

Materials

SIP-02	Crystal Growth
SIP-03	Carbon and Graphite
SIP-04	Physical Metallurgy
SIP-05	Powder Metallurgy
SIP-06	High Temperature Materials
SIP-07	Materials Joining Technology
SIP-08	Material Forming and Machining
SIP-09	Microanalysis and Properties of Engineering Materials
SIP-10	Non-Destructive Testing
SIP-11	Corrosion and Protective Coatings
SIP-19	Reinforced Plastics and Composite Materials
SIP-47	Glass and Ceramics
SIP-105	Powder Metallurgy
SIP-108	Materials Forming and Machining
SIP-110	Non-Destructive Testing
SIP-111	Corrosion
SIP-147	Glass and Ceramics
SIP-154	Plating and Coating with Metals
SIP-157	Testing of Metals
SIP-158	Testing of Non-Metallic Materials
SIP-172	Natural and Synthetic Textiles
SIP-187	Paper, Pulp, and Cellulose Products
SIP-198	Welding and Cutting of Metals

Mechanical Engineering

SIP-07	Materials Joining Technology
SIP-08	Material Forming and Machining
SIP-09	Microanalysis and Properties of Engineering Materials
SIP-10	Non-Destructive Testing
SIP-13	Bearings and Lubrication
SIP-15	Fluid Flow
SIP-16	Fuels and Combustion for Air Breathing Engines
SIP-23	Fluidics
SIP-45	Turbine Technology
SIP-49	Control Systems Analysis
SIP-68	Heat Transfer
SIP-71	Human Factors Engineering
SIP-75	Structural Analysis and Design
SIP-103	Diesel Engines
SIP-108	Material Forming and Machining
SIP-110	Non-Destructive Testing
SIP-112	Liquid Fuels
SIP-113	Bearings and Lubrication
SIP-119	Pumps, Compressors, Pipe, Valves and Fittings
SIP-123	Refrigeration
SIP-149	Control Systems Analysis
SIP-155	Hydraulic Control and Transmission
SIP-162	Steam Turbines and Machinery
SIP-164	Thermodynamics
SIP-166	Heating, Ventilating, and Air Conditioning
SIP-167	Boilers, Pressure Vessels, and Heat Transfer Equipment
SIP-174	Mechanical Power Transmission
SIP-176	Materials Handling and Storage
SIP-190	Electrical Power Generation
SIP-192	Internal Combustion Engines
SIP-195	Fluid Flow
SIP-197	Surface Transportation
SIP-198	Welding and Cutting of Metals

Physics

SIP-12	Nuclear Power Reactors
SIP-14	Aerial Survey Techniques
SIP-21	Temperature Measurement
SIP-22	Vacuum Technology
SIP-23	Fluidics
SIP-24	Laser Applications
SIP-25	Laser Research
SIP-26	Cryogenics and Superconductors
SIP-28	Infrared Instrumentation
SIP-29	Photography
SIP-48	Optics
SIP-50	Magnetohydrodynamics
SIP-52	Sensory Devices for Instrumentation

Physics (Continued)

SIP-63	Industrial Mathematics
SIP-70	Holography
SIP-126	Cryogenics and Superconductors
SIP-148	Optics
SIP-152	Sensory Devices for Instrumentation
SIP-194	Measurement and Measuring Instruments

APPENDIX D

FEEDBACK COMMENTS ON THIRTY-ONE RETROSPECTIVE SEARCHES PERFORMED BY ARAC

RETROSPECTIVE SEARCH FEEDBACK COMMENTS

P2911 - Provided general information on the subject.
"Most valuable part of the search was the accompanying general comments as the result of two passes through the literature with the conclusion that there is no ready-made answer."

P2948 - Provided general information on the subject, contributed a partial solution to the problem, and contributed to a possible product improvement.
"The ARAC researcher, Mr. Robert Bernardon, did a very good job considering the difficulty of the subject."

N3021 - Provided general information on the subject, contributed a possible process innovation, and contributed to a possible product improvement.

N3024 - Provided general information on the subject and contributed to a possible product improvement.

N3037 - Provided general information on the subject and contributed to a possible product improvement.

N3047 - Provided general information on the subject and contributed to a possible product improvement.
"Two of the relevants were the same as we had received on a DDC search."

P3-49 - Contributed a partial solution to the problem.

P3069 - Provided general information on the subject and contributed to a partial solution to the problem.

N3080 - Provided general information on the subject and contributed to a possible product improvement.

N3089 - Provided general information on the subject and contributed to a possible product improvement.
"Approximately 1/5 of the abstracts appear to be of sufficient importance to the study to warrant ordering of a copy. The search in general yielded a great deal of useful information."

P3119 - Provided general information on the subject, contributed to a partial solution to the problem and, on another case, contributed a possible process innovation.
"We appreciate ARAC contacting one of the authors on this request."
And: "We appreciate the articles sent relating to this problem."

N3126 - Provided general information on the subject, contributed to a possible process innovation, and contributed to a possible product improvement.
"As you indicated in your letter, you too, recognize that the specific information requested was not found. We appreciate the marginal data found; we can use it, but our engineer cannot."

N3153 - Provided general information on the subject and contributed to a possible process innovation.

N3174 - Provided general information on the subject and contributed to a partial solution to the problem.

N3175 - Provided general information on the subject and contributed to a partial solution to the problem.

N3180 - Provided general information on the subject, contributed to a partial solution to the problem, and contributed to a possible product improvement.
"A number of abstracts were incomplete because they were printed too close to right edge of page and the last word on every line is either all or partially missing."

P3218 - Provided general information on the subject and contributed to a partial solution to the problem and "provided invaluable background information" in one case. Provided general information on the subject, provided a full solution to the problem, and provided a new product or process, and "provided needed specific information for assessing the role of water and electrolytes in disruptions of the physiologic clock," in another case.

P3239 - Provided general information on the subject, provided a new product or process, and "provided the specific references needed." "A good job of retrieval."

N3247 - Provided general information on the subject, and contributed a possible process innovation.
"Marginal data also appreciated."

P3305 - Contributed to a possible product improvement.

P3306 - Provided general information on the subject and contributed to a possible product improvement.

A3387 - Provided general information on the subject, contributed a partial solution to the problem, contributed a possible process innovation, contributed to a possible product improvement, and provided a new product or process.

D3422 - Provided general information on the subject, contributed a partial solution to the problem, and contributed to a possible product improvement.
"Quantity and quality of abstracts is good. However, for summaries containing more than ten abstracts, I found it convenient to number the pages and record the pages of interest for future reference."

A3436 - Contributed a partial solution to the problem.
"Gave detailed information that our sources could not find or supply. Very pleased with quality and speed of service."

A3453 - Provided general information on the subject.
"The lack of certain information tends to re-affirm my previous opinion (based on my own searching) that such information does not exist; and, therefore, this search was very useful from that point of view."

A3629 - Provided general information on the subject and contributed a possible process innovation.
"Very useful--provided detailed technical articles on practically every aspect of EDM."

D3565 - Provided general information on the subject.
"Eleven references were received which I was not aware of. Two of the eleven were excellent references."

G3561 - Contributed a partial solution to the problem.

A3593 - Provided general information on the subject and contributed a partial solution to the problem.
"This information is exactly what I was hoping would be uncovered."

A3606 - Contributed a partial solution to the problem.
"Of the 25 references (abstracts) furnished, all but 9 were of interest, and two were quite useful."

D3638 - Provided general information on the subject and contributed a partial solution to the problem.
"I deeply appreciate your providing me with the small booklet of relevant abstracts on the cosmic radiation problem so promptly."

E3643 - Contributed a possible process innovation and provided a new product or process.
"The information on glass and ceramic microballoons was excellent. We didn't find any information on the plastic microballoon which we were also interested in."

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