A QUANTITATIVE TECHNIQUE FOR DESIGNING THE TECHNICAL INFORMATION CENTER

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WHAT HAS PRODUCED THE MODERN TECHNICAL INFORMATION CENTER?

Within the past generation, the technical information environment of the typical scientist has changed from scarcity to surplus. Our scientific forbears could "keep up with their field" rather comfortably. With the journals and other tools of their era, their capacity to scan for pertinence and digest for meaning essentially exceeded the rate at which significant new knowledge was being generated. For most of us that time is gone, and gone forever.

In most technical fields today the thoughtful scientist views his obligation to remain well-informed with a sense of acute personal distress. Almost certainly, the annual output in his own specialty has continued to increase. But beyond that, our great triumphs in merging science at the base have unblocked new areas, previously the specialty of another, in which he can also be competent. Self-interest, if nothing more, presses him to command them as well, or accept consignment to a relatively narrow and barren field.

A second major influence on the scientist has been the way our society has altered its expectations of him in the past generation. In fact, we have only to go back four years to Sputnik I to see quite significant changes, although the historic inflection point probably should date from the OSRD activities of World War II. Before then, the scientist really lived in a comparatively simple and undemanding world. He roamed pretty much where he pleased, and the terrain of a single discipline usually proved fertile enough to keep him happy and rewarded. Society pretty much looked on his useful discoveries as windfalls. Since it had not yet grasped the full implications of creative research, it issued no socially-motived directives and established no quotas for our scientists and technologists.

Today the individual scientist usually finds himself a part of large and complex technological endeavors. These endeavors reflect the rapid industrialization of science and the scientist. And, more and more often, they are addressed to the meeting of a social desire or need, which may be the conquest of a major disease, the creation of a new tool of national defense, or the enhancement of an economic resource. The scientist and his science bear the sobering responsibilities of cultural maturity.

In this new environment the scientist's information need cannot be dismissed as a uniquely personal concern. Increasingly it has become viewed as a responsibility his employer should share, most particularly with informational services that conserve the ever-more-sought talents — and ever-more-costly man-hours--of available technical manpower. This is the shift, we believe, that has led to the appearance of the modern technical information center.

The scientist's very endorsement of the information center concept suggests strongly that new forces of actual historical magnitude have come into play. Especially significant is the scientist's philosophical acceptance of the judgment of another in sifting subject matter through a storage-retrieval mechanism that he does not ever expect to operate personally. (It is true, of course, that he still is free to use other channels that give him direct contact with original material. But the fact that research scientists will even concede value to techniques requiring a third-party participant indicates the magnitude of the influences they feel.)

Because the information center is a young and yet-vulnerable institution (perhaps, in fact, the first undisputed child of an information-surplus technological culture), we believe those who would design and operate them should make a real effort, however scanty the current firm knowledge, to understand underlying forces, the practical limits they imply, and the special innovations they encourage. This is the time for intellectual rigor, so far as it can be applied.

With amply-justified humility we offer such an analysis. Later, we will describe how it affected some of our choices and interpretations in an actual design project.

DEFINING THE TECHNICAL INFORMATION CENTER

Any realistic definition of a technical information center must relate it to a larger functional system. This larger system contains, in addition to our center, information users and (since the use of knowledge almost invariably creates new knowledge) it contains information sources. Finally, the larger system contains a policy or managerial element. The executive element decides the users to be served and the sort of information and service the center is expected to provide.

Let us formalize an assertion from these comments:

> "The proper informational mission of a technical information center is a function of the technical mission of the population it serves." (ASSERTION I)

This assertion does not differentiate the technical library from the information center. We shall contend that the staff of the information center is professionally qualified in the technical subjects handled, whereas the special expertise of the technical library is the management of documents. In any real situation, we rarely find either information centers or technical libraries whose staffs are entirely unqualified in the other's domain. But if we attempt to fix the ultimate distinction between prime competencies that lead to totally different roles within the organization, we believe the test is the presence or absence of professional capability (i.e., capacity to function as a technical expert) in the subject matter.

In talking hereafter of a technical information center, we mean an organization that satisfies the following definition:

> "A group serving a technical organization or field by collecting and supplying pertinent technical and specialized information to other specified groups and individuals, and qualified and functioning in this role as a professional peer of those groups and individuals." (DEFINITION I)

The clause within this definition that reads "... functioning in this role as a professional peer....," calls for examination of one other prime question. The question concerns the resources the center must command to collect, store, search, retrieve, and communicate at peer level. To account for them, we suggest:

> "The information center's proper technical knowledgeability and subject range are determined by the technical competence of the persons being served and by the nature of the problems in which they are engaged. Its proper information-processing and -supply practices are determined by the knowledge patterns traditional in the special fields represented among those it is serving." (ASSERTION II)

It will be seen that a center satisfying Assertion II does not require those it serves to learn anything about its information-processing operations. This is possible because it has peer competence in the technical subject matter, and thus can "translate" its raw retrieval output from "information system" language to, say, colloid chemist language. In this respect, the center can make life distinctly easier for the person served than the "pure" library we defined previously.

Assertion II also implies that working knowledge of specialized information-processing techniques is not an inherent responsibility of the "bench" scientist. And as the opposite side of the coin, it implies that there is a distinctive field of expertise pertinent to information and communication processes. (We have heard "information scientist" with increasing prevalence, so we should perhaps call it "information science" — and its applied-art companion, "communication technology.") We believe that the rapidly advancing research in machine and non-machine storage-search-retrieval methods already has presented substantial justification for this very important claim. Machine data-processing, for example, may be a small part of the total information art, but it is important in special areas and certainly has demanded specialized training far beyond the tolerance of the person who is not a machine specialist.

The logical consequences of this line of reasoning produce guide-lines that we think are of primary importance when one actually gets down to the matter of designing or operating an information center. They include:

1. The designer should investigate the field-of-knowledge patterns, competency levels, personal attitudes, and working objectives of the group he proposes to serve. From these, he can derive the information service range and techniques that make connections with real customers at the other end of the line and are neither over- nor under-designed to serve them.

2. His information output should be purged of any characteristics imposed by the center's internal storage-retrieval techniques. (We will concede one departure from this ideal, when purging costs are greater than the combined effects of the educational costs and communication losses imposed on those he is serving.)

3. His staff must contain two professional competencies: in specified technical subjects, and in information science and communication technology. Key members of his staff must be knowledgeable in both fields.

4. He should view his staff as prime terminal vehicles for conveying information to the customer -- and for accepting it initially to the center. As information carriers, face-to-face discussions (or ear-to-ear telephone conversation) are impressively distinctive from the accession list, or even the individual memorandum. He should be most particularly aware of the novel ways in which the human can function as a component link of an information service system.

HUMANISTIC FEATURES OF THE TECHNICAL INFORMATION CENTER

When "science" and "man" are mentioned in the same breath, the first quick comparison that comes to mind--particularly to the mind of a scientist possessing the true faith--is the relative fallibility of the human when compared with the ordered beauty and reassuring reproducibility of scientific law.

Shouldn't we be doing our best to build information services that exclude the human, rather than making him the pivot component?

And isn't the added suggestion that the service be derived from the human interests of the group to be served really a sort of ultimate confession that there is no discipline or substance to this subject at all?

We believe neither is so.

Our earlier discussions do not really answer this very appropriate question, since they consist of a brief attempt at contemporary history and a recital of some implications associated with a few gratuitous definitions and assertions.

For our first advocate of the human ingredient in the technical information service, we offer the French philosopher-scientist du Noüy. Du Noüy advances the essential argument that "science" is inherently shot through with humanism. "Science," he says, "is only that portion of nature that humans have been able to make sense of through a process of rational ordering.[1]" If one follows du Noüy's basic contention to its application here, the human is the most fully compatible vessel for contending with scientific information, being its creator. Mechanisms (like index cards or computers) may aid the human but only rarely can carry value discrimination beyond the moron level. And professional scientists have only limited use for moronic services.

For our second fundamental argument in defense of the human ingredient, we offer R. E. Gibson, the scientist-executive-philosopher who heads the Applied Physics Laboratory of the Johns Hopkins University. APL originated and currently operates one of the first modern technical information centers, the Solid Propellent Information Agency. Gibson asserts:

> "Knowledge, the distillate of human experience, is stored in three types of banks: (a) in the human mind and memory; (b) in the literature--periodicals, books, reports, and so forth; (c) in the products of technology and culture, commodities, tools, services, and organizations. Of these the only bank which pays interest and offers capital gains is the mind. The growth of knowledge is a function of the capacity and the number of educated minds engaged in its cultivation.[2]"

So much for natural congruence of art and discipline with the human mind: what about human fallibility? To examine this question, we propose to review the conditions and consequences one might reasonably anticipate if he set up an information service.

Let us suppose you have been charged with the responsibility of designing a technical information service. Let us suppose further that a real organization, or field of interest, staffed with real scientists and engineers, with real laboratories—even real libraries and librarians—exists already to use and be used by this service you have been asked to design.

If you subscribe, as the authors do, to the belief that an optimal technical information service is a derivative of the population it serves, the logical outgrowth of your efforts should possess several gratifying characteristics:

1. Your recommended design should relate closely to the expressed interest of the population being served--which makes them happy (at least before the actual service is launched; it also helps in getting executive authorization).

2. In your design, you will find yourself virtually forced to take account of the firm data you were actually able to develop. This stricture reduces the likelihood that the "service" will really be an experimental vehicle for one person's untested theories. By no means, however, does it eliminate the opportunity for imaginative or unconventional techniques. It is more likely to stimulate innovations that have the notable added virtue of utility.

3. Even if your survey technique is creditable, there is usually enough "slop" in the returns that you can sneak a few of your pet techniques into less critical areas of the design. This usually means that the exercise leaves you happy.

So we finally get our service established--through steps we know include human fallibility. What happens then?

The normal design errors in such a system do not compound to absurdity or catastrophe like a runaway computer. For the characteristic strength of the humanistic element now comes into play. The staff members of a real technical information center, being human and able to recognize the technical shortcomings of initial operation, quite predictably will react to, compensate for, and ultimately correct the imperfections. Our basic strategy is therefore quite sound. This organic vitality of the modern technical information service, manned by professional scientists or engineers, permits--indeed, counsels--acceptance of design directives from a population that is not sophisticated in information technique per se. Just breathe life into the service by endowing it with a well-trained, service-oriented technical staff, and it will gravitate toward its optimal role. It will do more yet: it will follow the changing and evolving needs of the population it serves as the whole endeavor proceeds.

At first glance, one might conclude that an information service built to specifications laid down by the user does not allow us to make use of the more sophisticated information-processing techniques. This is not so. It does, however, illuminate for us the sharp distinction that should be made between the methods used within the service group and the techniques it employs in communicating with its "clients." Internally, the search-retrieval system may be technologically formidable. Externally, the output should be delivered in a format acceptable to the recipient. The recipient (even though he is a scientist) turns out to have human fallibility, too, and woe betide the system that fails to accommodate to him.

We might have a sense of despair on reaching the conclusion that all of science is really just that slim caricature of all human experiences that we have found organizable. But we might also view the emergence of the human-centered technical information center as heartening evidence that we have at last accumulated enough science that we can no longer subject our precious hoard to the intellectual crudities of non-humanistic mass processing techniques and still retain our grip on it. Its growing richness has just begun to make demands for something better--to be specific, those store-search-retrieval schemes that employ more effectively the subtleties and discriminating powers of the human mind.

BENEFITS OF OPINION QUESTIONS IN PRE-DESIGN SURVEYS

This leads us to a justification for soliciting opinion as well as fact when one sets about designing the technical information center:

If one predicates that (1) the person interviewed understands what you are asking him; (2) he is asked to answer only on behalf of himself, or a small group with which he is intimately associated; (3) he is made reasonably convinced that his personal practices, preferences, and opinions are inherently "right" answers to your questions; (4) a sufficient sample of the population concerned is polled to eliminate statistical uncertainties: we believe that a more complete and reliable specification for the proper information service has been established than specifications one can develop through other means, and most particularly through means restricted to non-opinion measurements. We believe this because the working success of the service ("center," etc.) depends so intimately upon subjective considerations, including such "unscientific" matters as the college degrees held by the center's employees, the official name of the service, and mass attitudes of the group being served. One should make positive efforts to draw out these subjective factors, so there is some reasonable chance of dealing with them effectively in the design.

These precepts underlie the specific techniques utilized in a recent study the authors have conducted.[3] A summary of the survey objectives, the approach used, and the service derived through the investigation are given.

A CASE HISTORY: DESIGN OF A TECHNICAL INFORMATION CENTER SERVING THE UPPER ATMOSPHERE TECHNICAL COMMUNITY[4]

Objectives of Project. -- The ARIES project had the broad purpose of determining whether a technical information service would contribute to current scientific and engineering programs concerned with knowledge of the upper atmosphere (the altitude range 30 to 300 km.) To accomplish this purpose, it was necessary to determine:

1. The merit of a service
2. The optimal technical coverage
3. The service techniques and staff requirements, and
4. The estimated annual operating cost.

The Survey Technique Employed in the ARIES Study. -- The investigation method employed had to:

1. Identify the members of the population.
2. Determine the technical information usage of an adequate sample of the population.
3. Determine the most acceptable service techniques for serving it.
4. Ascertain the desire of the population for a centralized technical information service.

Depth personal interviews, coupled with "cross-check" mail questionnaires on key points of the survey, were employed to obtain this information.

So far as possible, we chose persons at the "group-head" level for detailed interview-discussions, so a single interrogation would produce an informed appraisal of the involvement of all persons in the group with upper atmosphere data, and would yield a working-knowledge opinion of the technical information need.

Persons interviewed were asked to answer only on behalf of their own group, as we in effect synthesized a total population answer in our compilation of individual replies.

Size of Population Sample Surveyed. -- The typical group head supervised three to ten professionals. A single interview thus reflected the explicit practices and requirements of perhaps five to ten persons (including technicians as well as professionals).

The survey returns indicated that the following population sample was represented:

	Sent	No. respondents	No. professionals represented
Interview check-list	--	38	160
Mail questionnaire	80	39	575
Total	80	77	735

In addition, relatively significant discussions were held with approximately 35 persons under circumstances not resulting in a filled-out questionnaire. (The distribution of their attitudes regarding a service appeared consistent with the more formally obtained replies.)

Analysis of Returns. -- Statistical tests[5] were employed to determine the significance of the replies obtained from the sample population, and to see whether sub-groups in the population varied in their information usage and their desire for an information service.

The "do you want a service" answers in the interview sample and the mail questionnaire sample were cross-checked to see whether these different survey techniques indicated significantly different sample populations. (The test showed a very high probability that the populations were identical.)

To facilitate the cross-correlation process, a Keysort card transcript of all mail questionnaire and interview check-lists was prepared. Its model was the brief mail questionnaire. Tests of more detailed questions were made by hand compilation from the interview questionnaire.

DERIVATION OF OPTIMAL SERVICE DESIGN

Desire for an Information Service. -- The questionnaire data were analyzed to determine the desire of the technical population for an information service. The results were:

	Desire for Service, %			Desire	Statistical
	Highly	More	Less	Rating*	significance**
Interviewees (33)	55	24	21	1.67	Yes
Mail questionnaire (34)	44	44	12	1.65	Yes
Total (67)				1.66	Yes

*Composite of multiple-choice replies rating from -1 to +3.
**By X^2 test.

Subject Range of the Service. -- The data usage of the population was employed to establish the optimal subject coverage for the service. The results (10 subjects with the highest use ratings) are given, in rank order in the following table:

Subject Field	Use rating*	Statistically significant**
Density	1.84	Yes
Solar Radiation	1.4	Yes
Temperature	1.37	Yes
Winds	1.2	Yes
Pressure	1.1	
Ionization	1.05	Yes
0.8 ------------------------		
Water	0.63	
Oxygen	0.63	
Ozone	0.47	
Nitrogen Oxides	0.52	

*Composite of multiple-choice replies rating from -1 to +3.
**By t test.

Inspection suggested a cut-off value of 0.8 in defining the initial subject coverage of the service.

Technical Skills Required. -- The subjects ranking above 0.8 in usage value then were inspected to determine the technical skills desirable in the service staff. They indicate principal needs for professional knowledge of:

1. Physics (especially radiation phenomena)
2. Meteorology
3. Instrumentation (electronic and mechanical)

Service Techniques Desired. -- Interview check-list returns next were analyzed with respect to preferences expressed for different information service techniques. The results for the 10 service functions with the highest ratings follow, in rank order:

Technique	Desire rating*	Statistically significant**
Loose-leaf manual	2.2	Yes
Data collection-compilation	1.9	Yes
Accession list	1.5	Yes
Abstract bulletin	1.5	
Technical extract-reports	1.4	
Newsletter	1.2	
Report and document collection	1.2	
"Man Friday"	1.1	
1.0 ------------------------		
Language translations	0.85	
Handbooks	0.67	

*Numerical weighted average for population answering the questions.
**By t test.

Inspection of the spread of desire ratings suggested a cut-off value of 1.0.

These service preferences show a predominance of function requiring technical knowledge, and editorial rather than library skills.

The broad picture evoked by these preference rankings provides a rather explicit set of directives for the personal and information-technique skills, staff activity patterns, and physical resources of a service that will satisfy the demand. They are itemized as follows:

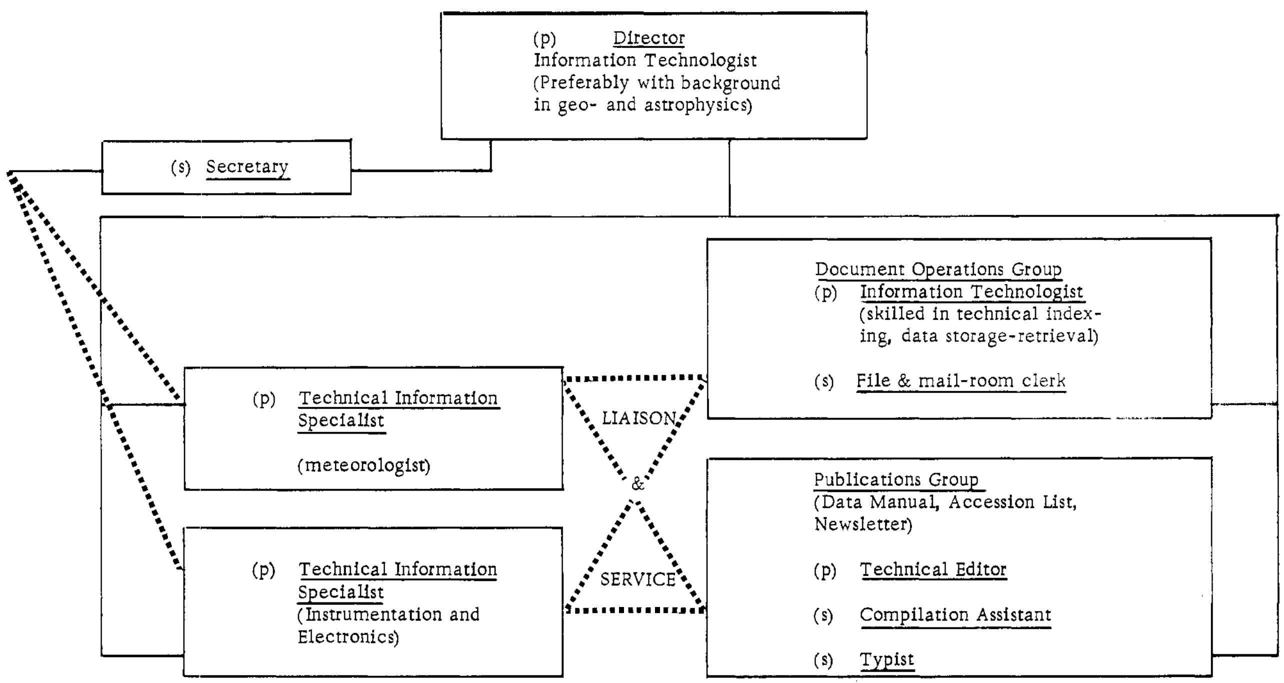
THE SERVICE SHOULD PROVIDE:

1. A data collection-compilation activity, with the compilations disseminated in

the form of "perpetual" manuals updated as appropriate with loose-leaf inserts.
2. Periodic announcements of new subject-knowledge sources acquired by the service. Periodic accession lists were recommended.
3. A newsletter. (We recommended that the newsletter function be provided as a "Progress Highlights" opening section of the accession list.)
4. The document collection necessary to conduct these activities.
5. Technical reportorial coverage of meetings and conferences.
6. "Man Friday" information services by staff members.
7. Technical editorial skills and personnel with the professional capacity to deal effectively on a person-to-person basis with project scientists and engineers.
8. An appreciable travel activity.

THE SERVICE DOES NOT NEED TO PROVIDE:
1. Conventional library services, such as document loans, book purchases, reprint ordering, etc.
2. Special correlations or mathematical services.
3. Administrative support in organizing meetings.

The Operating Service Organization. -- An organization chart for an information center performing these functions follows:



This pattern was chosen to provide a maximum assignment of specific work responsibilities to individuals, yet retain necessary flexibility for unusual work loads. Total staff includes four senior and one junior professionals (p) plus a supporting clerical-secretarial (s) force of four.

EFFECT OF CASE HISTORY SPECIFICS ON GENERAL METHOD

We suspect the ARIES case history was inherently kinder to the surveyor than many of the situations one might be called on to explore. To enumerate:

1. The sharp definition of subject field, namely, geophysical attributes of the atmosphere and rocketsonde technology, considerably eased the conception and preparation of the "morphology list," which we feel contributed considerably in gaining professional acceptance for the interviewer and technical consistency during interview discussion.

2. The population proved quite uniform in its attitudes regarding a service, thus producing key answers possessing high statistical assurance from relatively small samples.

3. This consistency also produced substantial concordance regarding the design for certain services and subject coverages. In fact, almost no interpretive judgments by the survey group were required to reconcile the replies with a set of realistic recommendations.

4. The service desires expressed were readily accommodated in an

organization of logical design and realistic size, manned by persons with conventional discipline training and career experience.

We may, of course, be leaning over backwards in this generalized judgment, in view of our introductory emphasis of the humanistic underpinnings of scientific fields. But we can readily visualize patterns of survey returns that would be much more difficult to cope with than ARIES proved to be.

Should we apply this basic survey technique to a more refractory problem, we do have available a few more tricks in our kit-bag that might spell the difference between a derived design and blind guessing. For example:

1. Fields of interest might be approached by asking more than one leading member of the survey population to outline it for us, and then looking to see where their replies coincide and diverge. In some instances, a field is really a number of "schools," loosely bound together by a common purpose, perhaps, but with distinctively different technical patterns. Where such characteristics are found, some of the service functions may properly be provided to certain parts of the field, while others may serve across the board.

2. Within limits, certain statistical assurances can be obtained by increasing the survey sample size. Should an initial sample show uncertain concurrence, we can examine the return, and by risking an assumption or two, get a reasonable indication of the additional surveying needed to clarify the ambiguities.

3. At times a particular service requested is explicit and technically justified, but the specialized training required and the fractional man-power called for make it clearly uneconomic to provide a properly qualified specialist in the centralized service. In such an instance, we might recommend that part-time information service duties be assigned to an appropriate specialist in the group requiring the service. In general, peer competence in the information service organization facilitates practical solutions that are not strictly observant of organization chart lines.

Finally, we wish to urge this key recommendation on any person assigned the task of designing an information service: begin by just looking at the situation with the greatest perceptivity you can bring to bear. At the beginning, try to avoid any preconception as to the methods you will use to develop firm guide lines for your design. For just as certainly as a sound design study can avoid unproductive costs in the operation of an information center, the initial natural disposition of persons, attitudes, and activities usually contains hints regarding particularly apt design solutions. If you can see them, they usually suggest singularly productive approaches to data collection, and stimulate the development of imaginative and unusually well-fitting designs.

REFERENCES

(1) Lecomte du Noüy, "Human Destiny," The New American Library of World Literature, New York, N. Y., 1949.

(2) R. E. Gibson, "Impact of Government Programs on Growth of Knowledge," Presented before the 134th ACS National Meeting, September 9, 1958, Chicago, Illinois.

(3) Project ARIES (Atmospheric Research Information Exchange Study), A Study to Determine the Merits of an Upper Atmosphere Technical Information Service. Contract Nonr 3071-00, Office of Naval Research. (Grateful acknowledgment is made to the Office of Naval Research, Code 416, for permission to utilize the results of that study for this paper. Information and opinions presented here do not necessarily carry the endorsement or represent the viewpoint of the U. S. Navy.)

(4) Check-lists and questionaire responses of this survey are available from the authors on request.

(5) H. C. Fryer, "Elements of Statistics," John Wiley & Sons, Inc., New York, N. Y., 1954.

ANTARCTIC STUDY

A survey of Antarctic information sources will be performed by Science Communication, Inc., Philadelphia, Pa., with NSF support. The survey will seek to locate documents, specimens, data, and other information on the Antarctic; investigate information requirements; and analyze information available to, and needed by, the U.S. Antarctic Research Program, administered by NSF.