of simple size. I suspect, although I have never tried to prove, that the square-cube law—that the surface increases as a square while the internal volume increases as a cube—that affects all living organisms also applies to information systems. One feels intuitively that the amount of surface area available for radiation—the transfer of information outside the system—increases at a slower rate than the complexities of interactions between the items in the store, and that both of these in turn tend to grow far more rapidly than does the nutrient supply of people and money needed to operate the system.

An interesting consequence of the square-cube law in nature is that it sets an upper limit to the size of organisms. You just don't build a terrestrial animal much larger than the present day elephant. I wonder if it may not also set an upper limit to the size of information systems; if the internal complexities are growing at a much faster rate than the public contact area, the manager inevitably becomes more concerned with the internal management rather than the public service.

It seemed a good idea in planning this symposium to retrieve the managers of four major Federal technical information activities from the midst of their information stores and give them a chance to meet the members of the Division of Chemical Literature. As operators of information systems we are interested in the ways in which their information systems operate; as consumers of the products of these agencies we are concerned with the uses we may make of their information systems.

The Science Information Exchange which Dr. Monroe Freeman heads represents a unique resource, an inventory of current research efforts in the life sciences and, increasingly, the physical sciences. The biological scientists learned to make good use of this agency in its former guise as the Biosciences Information Exchange. It is to be hoped that the physical scientists will make equally good use of it as its stores of information on projects in the physical sciences grow.

In my day to day life everyone I meet seems either to be a Department of Defense contractor or wants to be one. The central agency for secondary distribution of Department of Defense reports is the Armed Services Technical Information Agency of which Colonel James Vann is the Commander.

The Department of Defense has no formal responsibility for disseminating the results of the research it supports to those not in the DOD community. This has become, *inter alia*, one of the many activities of the Office of Technical Services, Department of Commerce, under John Green.

It is seldom that one has an opportunity to start with a clean piece of paper and design a major information system from scratch. The establishment of the National Aeronautics and Space Administration has given Mel Day that opportunity. Perhaps in NASA more than any other agency on today's program, the simple effects of simple size have necessitated many new and ingenious solutions to information problems.

Technical Information for Research Program Management*

By MONROE E. FREEMAN
Science Information Exchange, Smithsonian Institution, Washington, D. C.
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It is axiomatic that intelligent research begins with adequate information about prior experimentation as recorded in the scientific and technical literature. It is equally obvious that the problem of extracting the pertinent information from books, journals, abstracts, and progress reports has *now* become baffling, frustrating, and monstrous. Besides the vast number of records to be examined and their interdisciplinary complexities, there is the faster tempo of modern research. These have contributed critical significance to the pre-publication gap of information on research in progress. This hiatus of uncertainty between the start of experimentation and the time results appear in the literature now seems to average 1–3 years. It is to this one segment of the total technical information problem that these remarks are addressed.

This hiatus was not so critical when research proceeded at a leisurely pace, and when only a few investigators were intimately concerned with any one specific problem. Then, information on current research was fairly well exchanged at annual meetings, at symposia, by correspondence, and by casual meetings among the few principals. This is no longer the case, even in the fields of narrow specialization. No long ago, the Science Information Exchange entertained a visitor whose research specialty was whales. Since not many people specialize in whales, it was a surprise to find records on three whale projects of which the visiting specialist was quite unaware. Another subject brought out 34 records of research in progress at 31 different universities, including three Canadian, one English, and one Italian. These 34 projects were supported by grants from 22 different agencies, of which nine were different government agencies and 13 were

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different nongovernment foundations. It is apparent that research scattered so widely and supported by so many different sponsors is not easily located, identified, or coordinated by the traditional or haphazard methods.

The implications of timely information on current research activity may be illustrated by two terse letters from the Exchange files. One, from a large industrial laboratory, acknowledged receipt of current research summaries and noted that two of them described research they had intended to start next week. On the other side of the coin was the writer who ruefully admitted he had worked for two years on a project only to find himself scooped last month.

The need for information on current research became quite apparent 10 years ago when Federal research programs in medicine and the life sciences began to increase rapidly. About 1949, the administrators of major Federal research programs recognized the difficulties in the managing of such programs without adequate knowledge of other work being planned or actually in progress. A 1-3 year information gap could have important influence on the planning and conduct of multimillion dollar programs.

These considerations prompted the establishment of the Medical Sciences Information Exchange by Federal agencies. They agreed to furnish information on all research grants, contracts, and in-house research. The Exchange undertook to organize and disseminate the information that could assist research directors and administrators. The scope quickly expanded from medicine to related fields of biology and it became the Bio-Sciences Information Exchange in 1953. Eight years later it was expanded to include physical sciences and was renamed the Science Information Exchange.

Two unique features of this enterprise should be emphasized. First, it deals only with records of research actually in progress before it has reached any publication and documentation channels. Progress reports, abstracts, journal articles and other forms of documented results are not collected. The Exchange does not duplicate or compete with the established library and documentation services. Actually it complements these by covering only the pre-publication phase of the total process. Second, the Exchange features the development of many different arrays and compilations of information that are tailored with each request to meet a specific need of research management.

Information on current research activity comes from many sources: participating Federal agencies; about 70 nongovernment foundations and fund-raising organizations supporting research at the national level; state government research agencies; universities; industry; and individual investigators. The Exchange accepts records from all sources that wish to register and endeavors to establish cooperative arrangements with all research support organizations that are interested in contributing information about their programs.

Approximately 60,000 records of proposals, grants, awards, contracts, and projects are received annually. The data arrive in many different forms according to the different administrative procedures of the many different sources. In any case, these data are reduced to a single page document that is the basic input and output document of the Exchange. This *Notice of Research Project* records six essential items: (1) supporting agency; (2) names of principal and associate investigators; (3) title; (4) location of the work; (5) 300-word summary of the research planned or in progress; and (6) level of effort in terms of grants and dates.

About 40,000 projects are carried in the currently active files. When a project is terminated, the record is retired to microfilm files that are accessible but in less demand. These terminated files go back to 1948 and contain about one-quarter million records. At present the bulk of the S.I.E. collection is biology, medicine, psychology, and sociology. Records on physical sciences research began to arrive a few months ago but will not reach useful or comprehensive proportions for some time. The items noted above are coded on magnetic tape, so that names, locations, agencies, and subject matter can be retrieved in any desired combinations. The alphabetic name list of all principal and associate investigators allows the retrieval of the current research of any individuals. About 90,000 active research workers are so listed. By coding all records to a location, *i.e.*, country, state, university, college, and department or the organizational equivalent, all work registered from one chemistry department, or from all chemistry departments, can be selected. The total program of any agency, or any part thereof, can be retrieved if requested by that agency. The work described in the summary is analyzed and indexed by a staff of professional scientists to about 8,000 subject matter categories. Any combination of individual, location, supporting agency, subject matter, level of effort, etc. can be programmed to quickly develop information in response to questions on the current research activity as it is registered in the Exchange.

Since all the information registered by the Exchange is prior to publication, its dissemination is necessarily restricted to the scientific community for limited purposes, and S.I.E. may answer inquiries only from scientists or engineers who are associated with recognized research organizations. A review of many questions received over the past few years has not revealed any pattern of meaningful repetition. Therefore, bibliographical lists and periodical publications are not prepared. All information is furnished only on specific demand in response to specific questions.

Since program management information is a feature of these services, the kinds of questions and answers vary widely according to the specific needs of the requesting agency or individual. In this connection, it is important to note that each agency has its own management practices and procedures, and their requirements for information differ accordingly. However, three general classes of requests are indicated by some years of experience. First, information on the current activities of applicants for grants or contracts has been in strong demand by agency officials and awards committees. On request by participating agencies, the Exchange forwards records of all grants, contracts, or pending proposals registered in the Exchange under the name of applicants. These records tend to give the granting agency some further insight into the nature, scope, and specialization of the applicant's research. In 1962 about 25,000 requests for this kind of information were received and over 100,000 copies of current research records were returned. Some agencies

use another approach to the same problem. On receipt of a proposal they ask the Exchange for all other records that deal with the same or closely related subject.

A second class of management information commonly requested varies so widely that it can only be described by illustration. For instance, when one agency convened consultants to review its program in orthopedic surgery, the Exchange supplied copies of all work registered from all sources to assist this panel in evaluating areas of over and under emphasis. Another agency official asked for all current work going on at a specified chemistry department as background information for a visit. In another case, a list of all active investigators in a special field was requested in order to select participants for a symposium. One agency asked for all United States grants, government and nongovernment, currently active in a South American country. Another request was for the total government and nongovernment money being spent on cancer research in the state of Pennsylvania. One agency requested a computer print-out of 13,000 projects arranged by specified subject categories, by state, by universities, and by departments. A recent number of the Congressional Record carries an S.I.E. table showing the distribution of $43,000,000 and 1,700 government and nongovernment grants among 16 selected categories of pharmacological research. These few examples serve only to illustrate the variety of requests for special kinds of information developed specifically for management purposes. Hundreds of such requests are filled each year. Some are short and simple. Others may require many hours of machine time. They are never predictable. They are often requested on a few hours notice.

The third class of information deals with subject matter primarily in answer to questions about *who* else may be working on *what* problems or projects. This service is of such common experience that it does not warrant detailed reference here. It is noted in passing, however, that this service is available to the scientific community in general. As noted above, it does bring together on one place the records of current research from many different agencies and references the research going on at many different research institutions throughout the United States and overseas where the work is supported by American funds. The technical detail of these research summaries is analyzed and indexed by professional scientists at the M.D., Ph.D., and M.S. level in order to insure full comprehension of the intent, inferences, and implications intended by the author. The same professional staff answers all subject matter questions in order that the communication link between the scientist who wrote the summary and the scientist who wants to know will suffer the minimum loss and distortion. The staff scientists retrieve by computer search or from visible files according to their professional judgment and comprehension of the question and its implications.

In this discussion, attention has been focused on only one phase of the total problem of scientific and technical information and its communication. It remains to place this function in its proper perspective, especially in regard to the vast government complex of information services. As indicated above, this approach complements the traditional library and other documentation services. It bears directly on the problem of timely information for management purposes at all levels from the individual investigator to the director of major programs. This management aspect of scientific and technical information is becoming the center of increasing interest and some controversy. Multimillion dollar research programs that encompass thousands of diversified projects and tasks need some information service for management and control, and such information systems are being developed by many agencies. At first glance, it might seem that herein lies duplication of effort since they apparently collect, manipulate, and organize quite comparable basic information. And it might follow that a single giant monolithic system, collecting all scientific and technical information and serving all purposes might answer this communication problem. However, a working familiarity with the detailed operational problems renders this view unattractive and impractical within the present state of the art, which seems to consist of as much speculation and theory as practical experience.

However, there is one aspect of the many information systems which does not seem to have had the attention it deserves. It seems quite evident that each agency has, perchance and perforce, developed characteristic and often unique management practices and procedures. These are dictated to a large extent by the nature of its research work and its own objectives. It should then follow that each agency may have quite different requirements for different kinds of information, and for effective use, the information must be organized and tailored accordingly. S.I.E. has been working with many different agencies, government and nongovernment, and has found that these needs do differ widely from one agency to another. From this viewpoint of practical experience, it can be argued that most agencies may very well need their own internal information service to deal with the information generated in their own programs, organized and designed specifically for their own internal management and internal control. This limited objective, limited in terms of its use and purpose, can probably be served most efficiently and effectively by the agency itself because each agency knows its internal management and control problems better than anyone else. Industry offers many examples of efficient information systems designed to meet limited objectives. In these cases, the limitations are usually in terms of technical fields rather than management criteria, but perhaps the analogy is not too finely drawn.

There still remains to be considered the role of inter-agency information exchange, a role that was assigned to S.I.E. some 12 years ago. Actually, S.I.E. has performed many services that could be done by the agencies themselves if they had their own internal information systems. Increasing development of these will allow more concentration on the problems of inter-agency exchange, not only among government research but among nongovernment agencies. Some opinion discounts the need for a central clearinghouse or inter-agency switchboard on the basis that agencies can exchange information directly. This may be workable among a few agencies with compatible systems, but anyone who has ever lived on a 25-party telephone line in the back country is well aware of the value of a central switchboard, especially if subscribers speak different languages. The typical request referenced above that brought together work supported by

22 different agencies and carried out in 31 different organizations is a case in point.

Consequently, it does not seem unreasonable that many agencies with major research programs have, and will continue to develop information systems specifically designed and oriented to their own internal control purposes. Attempts to standardize these different systems or to enforce compatibility among such systems must recognize the *basic fact* that management practices and procedures are *necessarily* different. To standardize the information systems that serve research management, suggests that management practices be standardized to make most effective use of the information furnished. Standardization of research management begins to sound like the standardization of research itself—a wholly untenable suggestion that in itself advises a careful analysis and review of the purposes, the objectives, and the uses of information systems before assuming that they be the same merely because they deal with the same basic stock of scientific and technical data.

Defense Documentation Center (DDC) for Scientific and Technical Information

By JAMES O. VANN
United States Air Force, Defense Documentation Center, Cameron Station, Alexandria, Virginia
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DEFENSE DOCUMENTATION CENTER MISSION

ASTIA—the Armed Services Technical Information Agency—has been renamed the Defense Documentation Center for Scientific and Technical Information—DDC. The change signifies greatly increased responsibilities given DDC in Department of Defense (DoD) Instruction 5100.38 dated March 19, 1963, and now being implemented by the Army, Navy, Air Force, and other DoD components. Most important, the change provides an opportunity for a systems approach in the handling of scientific and technical documents in the DoD.

For the nation's 400,000 defense related engineers and scientists, there are five objectives in the new Instruction that are particularly important to them:

1. **Acquisition of all DoD Scientific and Technical Documents by DDC.**—The only limitations involve categories where there is comparatively little scientific and technical information. Under former directives the best ASTIA could claim was to be the principal documentation center of the Department of Defense. It will now be THE Defense Documentation Center with all the meaning the definite article conveys.

2. **Prompt and Well Indexed Announcements of Newly Acquired DoD STI Documents.**—ASTIA has long recognized the need for well indexed announcements but lacked the resources to provide them. Now such indexes are specific requirements. Manpower and an advanced electronic data processing system are being provided which will support these efforts. This will speed decision-making in the selection of documents by engineers and scientists.

3. **Timely Dissemination of Scientific and Technical Documents to the DoD Community.**—The new instruction includes a number of objectives, functions, and authorities which will not only speed the DDC secondary distribution but will ultimately improve primary distribution.

4. **Maintain a Clearing-house, in the Form of an Index of Current Research, Development, Test, and Evaluation (RDT & E) Programs.**—Under the supervision of the Director of Defense Research and Engineering the Agency has already made a start on this service, but the new Instruction emphasizes the task.

5. **Establish a Centralized Directory and Provide Referral Service on Available DoD-Sponsored STI Activities.**—Under the new Instruction, DDC coordinates with DoD Specialized Technical Information Centers as a part of the integrated DoD system.

These are only five of the twenty objectives and functions assigned to the DDC by this new Instruction. They are implemented by a six-page enclosure which details acquisition and security procedures, authorized dissemination of classified and unclassified information, participation of DoD activities, and disposition of classified information disseminated by DDC. Most of these other objectives and functions continue responsibilities which ASTIA was carrying out, such as its Custom Abstract Searches and special dissemination services of its holdings and acquisitions.

Army, Navy, Air Force, and other DoD components have been directed to provide implementing instructions by Dr. Harold Brown, Director of Defense Research and Engineering (DDR & E) of the Department of Defense. The DDC Instruction is based upon a previous DoD Instruction No. 5129.43 issued January 22, 1963, and entitled "Assignment of Functions for the Defense Scientific and Technical Information Program." This first Instruction defined the types of STI functions in the program and established the position of Director of Technical Information on the DDR & E staff. Mr. Walter M. Carlson, a chemical engineer formerly with DuPont, has been appointed to this position. The new DDC