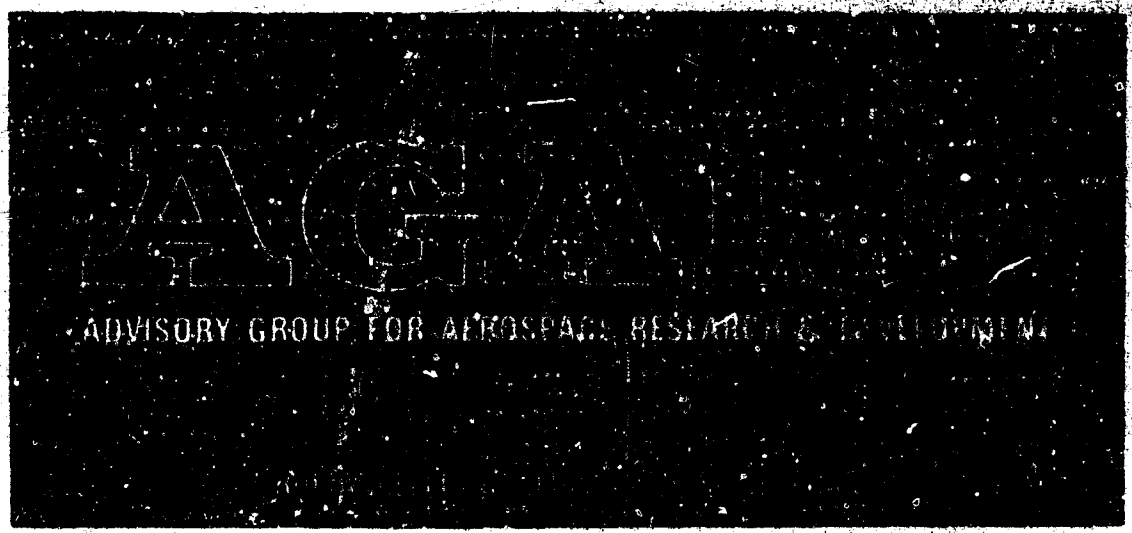


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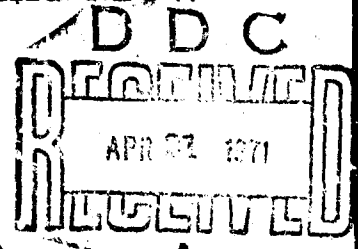
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LECTURE SERIES No. 44

OR

**Scientific and Technical Information
Why? Which? Where? and How?**



NORTH ATLANTIC TREATY ORGANIZATION



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AGARD Lecture Series No.44

NORTH ATLANTIC TREATY ORGANIZATION
ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT
(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

SCIENTIFIC AND TECHNICAL INFORMATION
WHY? WHICH? WHERE? AND HOW?

This Lecture Series, organized by the Consultant and Exchange Programme and sponsored by the Technical Information Panel, was presented in Oslo (Norway) and Rome (Italy) by the authors on 2-6 November 1970.

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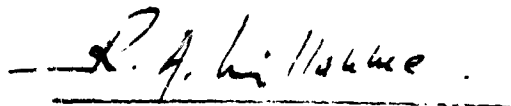
PREFACE

This Lecture Series, sponsored by the Technical Information Panel (TIP) and the Consultant and Exchange Programme of AGARD, was presented in Oslo (Norway) on the 2nd and 3rd November, 1970 and in Rome (Italy) on the 5th and 6th November, 1970.

The principal objective of this Lecture Series was to bring to the attention of users (Technologists and Scientists) the present capabilities of information systems, services and media retrieval techniques.

As in all branches of Science and Technology, automatic methods are playing an increasing part in Information Science and this was reflected in the lectures which were presented by leading experts in the field. The Series covered the basic background to what information can do for Scientists and Technologists, the needs of the technical community, sources of technical information, information channels and formal services for obtaining information together with a review of selected dissemination of information (SDI), a technique for providing announcements of a limited number of documents of specific interest to individuals or groups. The concept, mission and operation of scientific and technical information analysis centres was presented and the relationship of analysis centres to conventional information centres fully described.

Each series was concluded by an open forum and Scientists, Technologists, Information Officers, and Librarians from 10 NATO nations participated in this Lecture Series.



R.A. WILLAUME
Director, Plans and Programmes

AUTHORS

Lecture Series Director:

Mr H.A.STOLK
National Aerospace Laboratory
Amsterdam
Netherlands

Speakers:

Miss S.IRONSIDE
Department of National Defence
Ottawa
Canada

Mr J.MURDOCK
Battelle Memorial Institute
Columbus
USA

Mr S.C.SCHULEK
Ministry of Technology
Orpington
UK

Mr G.SIMPSON
Battelle Memorial Institute
Columbus
USA

Mr J.STEARNS
NASA Headquarters
Washington
USA

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INTRODUCTORY PAPER

by

H.A.Stolk

**National Aerospace Laboratory (NLR),
Amsterdam**

Chairman Technical Information Panel, AGARD

INTRODUCTORY PAPER

H.A.Stolk

Over the years the Panel has discussed storage and retrieval of information and in 1968, together with the Avionics Panel of AGARD, it organized and presented a symposium entitled "Information Storage and Retrieval: A User Supplier Dialogue".

This symposium was held principally for the benefit of scientists, engineers and management personnel who use information services, inviting them to comment on the present state-of-the-art, on the basic design of future systems and to point out their needs. The dialogue, however, was only partly successful in the sense that "user needs" were not comprehensively defined.

As a result of this it became clear that in the future the Panel's attention should be more actively directed at the user. In this context the presentation of a series of lectures to familiarize the user with the various aspects of the information environment seemed an appropriate means to pursue the dialogue. This appeared all the more desirable because evidence collected by means of so-called "user studies" tends to confirm the information organizer's point of view that the user hardly exists.

It is rather distressing to find that our information systems which have been developed with great effort and at tremendous costs to a high degree of sophistication seem to be missing their goal. Unquestionably a wealth of information is stored in today's mechanical systems but somehow the system operator does not fully succeed in retrieving that which the user wants. After a number of failures the latter gets more or less disgusted and stays away. Does this imply that information systems from a cost-benefit point of view are hardly, if at all, justified? In answer one might ask what the cost would have been without them.

It must be agreed that system operators have mostly directed their efforts at coping with the vastly increasing amount of published knowledge thereby neglecting to a considerable extent the user and what he needs. The increasing speed and memory capacity of the computer made it possible to register this published material and make it accessible but in a way that it is not directly suitable for subsequent use.

On the other hand, the user, who is a potential generator of information himself has not facilitated the task of the system operator. His increasing urge to publish, motivated or unmotivated, of good or bad quality, an addition to, or a duplication of, already existing knowledge is giving the system operator a very hard time.

As the situation is now, there exists a gap between those who supply information and those who use it. This gap should not become wider though it may not be closed altogether. There are ways for establishing bridgeheads on both sides which may be gradually expanded. The principal condition herefore, however, is the suppliers' preparedness to include the users' behaviour and needs in their concepts rather than losing themselves in ever more sophisticated and costly systems, while on the other hand the users should be open to appreciating the effort made on their behalf and cooperate in finding a mutually satisfactory compromise. We from our side like to point out what we can do for you while you from your side can indicate what you expect of us.

In the present lecture series the product being considered is technological information that exists in the form of printed words, graphs, tables, pictures, specifications, etc. and major attention will be focused on the question of how this information can be transferred.

A topic not covered by this lecture series but of equal importance as the transfer of technological information, is the transfer of technology. It therefore seems appropriate to discuss it briefly in this introductory (a more comprehensive analysis of the problem is given in "Selected Papers from a Seminar on the Management of Technology Transfer, UCLA, March 1968" published in IEEE Transactions on Engineering Management, August 1969).

Technology is a resource which exists in patents, processes, and procedures for research, engineering and manufacturing. It consists of designs for products, tools, and test equipment, of analytical methods and techniques of capabilities for problem solving, analyzing, designing, and testing. Frequently it is stored and remains in people's heads and cannot be found in documents. As Dr Charles Kimball, President of Midwest Research Institute, described it "Technology transfer involves the extension of the use of a technology in whole, or part, in areas beyond the initial use or application and usually by different persons the technology is new to the person who needs it, or uses it, and not necessarily new to the technical world in general". At the centre of this technology transfer

process, which is variously called "liaison", "interface" or "coupling" is the business firm and the major problem today is how industrial organizations can best manage it. The technology transfer process, in particular the speed of transfer, depends a great deal on managerial methods and structures. Therefore it is rather remote from the techniques and methods that will be discussed these two days. Fundamentally technology transfer refers to ideas and therefore to the man, as he has the ideas. Improved communications among men make the technology transfer process more efficient (committee meetings, seminars, moving the man with the knowledge to the point where the knowledge is to be applied, etc.). Technology transfer already is a big problem within a single company, but small compared to the problem of transferring technology from defence industry to non-defence problems. Here motivation and permission play an important role.

Management of technology transfer is perhaps best developed in the aerospace companies but these techniques are not easily and readily applied to other activities. In the future better coupling mechanisms will have to be developed in order to reduce the gap between the producers of new technology and those who must use it. The information analysis centres which will be discussed hereafter represent such a coupling mechanism.

Returning to the topic of this lecture series, one of the major problems of today is the abundance of information, a problem so basic that there is not even consensus of opinion with respect to its seriousness. Some people tend to belittle the importance of the problem, e.g. research workers who are well-established in their particular field. Others, on the contrary, believe that the available information is not efficiently utilized or fear that research is unwittingly duplicated. However, everybody seems to agree that quick, selective retrieval and dissemination of information are desirable.

The development that will probably do the most to solve this problem in the future is the *information network*. Through its many participants it will have greater resources and faster access than any of our libraries and information centres could hope to have today. This interconnection of existing information services should eventually make it possible to supply all kinds of information to all corners.

To modify our present system -- which is composed of many independent units, each going their separate way in terms of plans, resources, maintaining particular data bases or using commercially available ones -- into an efficient network clearly seems to be a responsibility of the government.

Each of you, whether you realize it or not, plays an important part in the transfer of information from one medium to another. In this regard, I would like to quote from the famous Weisberg Report entitled "The Responsibilities of the Technical Community and the Government in the Transfer of Information" in which he states:

"Transfer of information is an inseparable part of research and development. All those concerned with research and development, individual scientists and engineers, industrial and academic research establishments, technical societies, Government agencies -- must accept responsibility for the transfer of information in the same degree and spirit that they accept responsibility for research and development itself. The technical community generally must devote a larger share than heretofore of its time and resources to the discriminating management of the ever increasing technical record. Doing less will lead to fragmented and ineffective science and technology."

The last decade has been an era of increased awareness of the problems inherent in the field of information science. This lecture series and others like it give open evidence of the serious thought that is being expended on the techniques and science of all aspects in this field.

WHAT CAN INFORMATION DO FOR YOU?

by

Alice M. Ironside

*Deputy Director
Defence Scientific Information Service
Defence Research Board, Canada*

SUMMARY

Before a person is asked to play a significant part in collection, transfer or use of information, he should be appropriately oriented and motivated.

To this end a philosophical, non-technical approach is used to demonstrate that information is both an inherent part of life and a part of the fabric of living. Information is being presented to the individual continuously throughout his life, by his own senses, by other people and by the various media of communication. This information may be unheeded or heeded, and stored in his memory. It may also be stored in suitable forms by mechanical, electronic and other means. Once stored, it may be later retrieved and applied to any appropriate purpose.

Information is increasingly being recognized as a prime resource. Likewise the problems of maintaining the store of this resource and of its exploitation are being recognized and their solutions sought.

SOMMAIRE

Avant qu'on ne puisse s'attendre à ce qu'une personne joue un rôle important dans le rassemblement, la transmission ou l'emploi de l'information, il faut voir à ce que cette personne soit convenablement orientée dans ses idées et bien motivée.

À cette fin, l'emploi d'une approche plutôt philosophique et non-technique s'impose; il faut démontrer que l'information, ainsi dite, est à la fois partie intégrante et élément inévitable de la vie. Pendant tout le cours de son existence l'individu est sans cesse exposé à l'information, fournie par ses propres sens, par d'autres personnes, ou par les diverses modalités de la communication moderne. Cette information, on peut toujours la rejeter, ou bien on peut l'accepter et l'enregistrer dans la mémoire. On peut aussi l'enregistrer sous forme appropriée par des moyens mécaniques ou électroniques (ou autrement). Une fois enregistrée, elle peut être retrouvée plus tard, pour servir à tout besoin pratique.

De plus en plus on se rend compte que l'information constitue une ressource primaire des plus importantes. En même temps on reconnaît les problèmes du maintien et de l'exploitation de cette ressource, et on en cherche les aptes solutions.

WHAT CAN INFORMATION DO FOR YOU?

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*Deputy Director
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The abstract of this paper begins by stating "Before a person is asked to play a significant part in collection, transfer or use of information, he should be appropriately oriented and motivated." Before considering the collection, transfer or use of information let us consider both information itself and the persons involved.

Has it ever occurred to you that each of us is a product of information? If you are skeptical about that statement now, it is hoped that before the end of this paper you will be convinced of its validity. (If you are already convinced you may be good enough to supply additional points or bring up points of disagreement during the discussion which is to follow in approximately 30 minutes.)

Several thousand years ago the psalmist David wrote poetry on many subjects. One of his poems in praise of God contains lines that have been translated in the King James version of the Bible to read, "Thine eyes did see my substance yet being imperfect, and in thy book all my members were written, which in continuance were fashioned, when as yet there were none of them" (1). What a quaint yet surprising description of the genetics of the early decades of the 20th century and of the molecular biology and chemistry of the gene itself, by mid-century!

Today, scientists are able to describe the results of their painstaking research in these areas more precisely, possibly like this. In the cells of plants and animals, protein molecules of great significance appear to have been identified. Further investigation has shown that these molecules contain coded information which when deciphered, reveal the plan for cell differentiation, organization, and the eventual development of each species of plant and animal. Favourable micro and macro environments are essential to the fulfilment of the plan. It has similarly been demonstrated that the individual physical and chemical differences can also be traced to the information coded in the protein molecules of the genes (2).

Scientists continue to vie with each other in unfolding the mysteries of how the instructions in the protein molecules DNA are executed by its fellow nucleic acid molecules RNA. Some scientists have concluded that a dictionary of genetic codes plays a part in following the instructions.

The large body of well documented evidence already accumulated leaves little doubt that the physical characteristics of species and their variation within species, are directly related to the pattern meticulously coded in the genes.

Is there equally convincing evidence that other characteristics such as personality, are minutely detailed in nucleic acids? Or, is personality the product of our early environment, or is it due to a combination of environment and inherited or non-inherited cellular chemistry? We will leave the anthropologists, psychologists and biochemists to answer this age-old question; possibly in new terms as new facts are gleaned during their task of unravelling this complex subject.

A multi-disciplinary scientific effort however is not needed to convince most of us that regardless of physical characteristics people differ from each other. Each has a different mix of traits which may be difficult to define, yet most of us have some idea of the meaning of terms like personality, temperament, spirit, and intelligence, to suggest a few. We have seen that strong and colourful personalities attract or repel each other and are thankful for the personalities which produce harmony and give stability in human relationships. We know that people with one temperament adapt readily to a changed environment, whereas people with another temperament may be slow to make the necessary adjustments (3). One person accepts or becomes resigned to circumstances which another, who is possibly more resourceful and confident, takes steps to change. Most people are drawn to that which pleases but seek to avoid that which displeases. What pleases or displeases, however, varies from individual to individual and from time to time, often according to the mood of the moment.

Intelligence, in varying amounts is known to play some part in developing, modifying or stunting the expression of the other characteristics. Need we remind ourselves of the importance of the will, which is so much ours to control? Yet many of us find that it is not readily amenable to intelligent control.

Let us continue this unscientific approach by stating that our physical bodies are the implementation of the plan laid down in our particular set of genes; that our bodies are the vehicle through which these less well-defined but cardinal characteristics, whether or not attributable to our genes, perform.

What of the stage? It is crowded, not overpopulated in the areas most of us are fortunate to occupy, but crowded with material and non-material stimuli, seen and unseen, heard and unheard. We are normally unconscious of many of them, as we are unconscious of the air we breathe or the metabolism that uses the air to sustain life. Familiar sights and sounds tend to be taken for granted. They may only intrude on our consciousness when one of them is no longer present. The hawkers of merchandise are constantly seeking the new and the different to attract our attention, yet persist in mass producing the articles for sale so that both novelty and uniqueness are lost. Money is the one stimulus we are not allowed to ignore for long.

For a different reason, stimuli like the sudden prick of a rose thorn cannot easily be ignored, nor can the finger that has been pricked. The more subtle beauty of the rose however, or the delicacy of its fragrance may go unheeded.

Then there are the radio, the television, the stereo high fidelity records, newspapers and magazines with their lists of plays, cinema pictures, concerts, sports events, art galleries and museums, lectures, botanical gardens, zoos, restaurants and night clubs, cruises, flights to exotic lands, each striving for our attention and patronage.

Even during sleep, rapid eye movements are known to indicate mental activity in the form of dreams. These peculiar distortions of time and space with their Picasso-like people and animals, intrude into our unsuspecting brains when their critical faculties are dozing. The body is also known to rest well only if it changes position a number of times during sleep when the muscles signal the need for change.

It would appear that life is a continuum of stimuli. Information is embedded in the stimuli and it is to this that individuals react consciously or unconsciously. How do people cope with such a constant bombardment?

Some don't. They move to sparsely settled areas where amenities are reduced, income is lower but so too are the stimuli. Others seem to prefer to remain physically in the urban turmoil. Some of them use tranquilizers to dull their senses while others use drugs to increase their self-awareness. Still others lose their sanity, are hospitalized and given prescribed drugs and other forms of treatment which enable them to return, at least temporarily, to an environment which proved to be too much for them. Most people, fortunately, do cope.

If we look at our acquaintances, friends, family and at ourselves, we are likely to find among them, the bored, the over-stimulated and the well-stimulated. Each has established a behavioural pattern which is individually more or less satisfying.

Spicy bits of gossip, news of the latest catastrophes, the price of alcohol and tobacco, the high taxes imposed, and television thrillers may be all that registers on the consciousness of the bored and time hangs heavily. The over-stimulated, on the other hand, are aware of and are interested in all sorts of information from all the media. They eagerly attempt to follow everything in the daily press, magazines, radio, television, books, plays, concerts, and football in season. Unfortunately this accumulation of superficial ideas and facts, all too frequently, like the seed that falls on already oversown soil, is unproductive.

It remains to be seen if the findings of sociologists studying the effect of urbanization, offer hope for the over-stimulated. The findings suggest that as the number of stimuli in our surroundings increase, we are forced to screen out more and more of those which do not concern us directly. This screening tends to be subconscious rather than deliberate.

The well-stimulated have already developed a screening procedure. Stimuli are filtered out, consciously or subconsciously, which are unrelated to the pleasures, interests and purposes of such an individual.

We might pursue the thesis further, that man is a product of information, by considering the environment in which he lives. Given a physical environment that maintains a fit body, a healthy mind and a socially acceptable temperament, does cultural environment have an effect on us?

There seems little doubt that the answer is "yes". We need only to compare ourselves, when under thirty years of age, with the now-famous under-thirty age group of today.

Since history seems to teach that changes in society are reflected in art forms first, we will look at but one area, that of folk and popular music during the past thirty to forty years.

To the over-thirty, and I'm thinking of those well over thirty, the words of songs were about the day-to-day life of the people at work, or play. The moods were romantic, humourous, sad, or nostalgic. The tunes and tempos were composed to suit the words. The feet followed the tempo of the popular songs with light happy steps as the bodies, gaily dressed, moved rhythmically to the music. For many of us here, the beat changed abruptly, the steps became the disciplined tramp of marching feet.

How different to see today's youth, "the under-thirties", sitting motionless, or gyrating with feet glued to the floor, intent, listening, through a tremendous volume of sound, and a pulsating beat to words expressing the thoughts of their day.

The bodies and temperaments of this age group were inherited from their parents, so are unlikely to have altered radically in one generation.

The words of their songs in Canada do not reflect working on the railroad, the roaming buffalo, "Yes we have no bananas today", or "Tiptoeing through the tulips", with the love of the moment, or the love that continued and matured. No, they are telling about life as they see it, with realism, cynicism and humour. They see a need for love, for sharing, and for anarchy. They sing about pollution, about "Walking a mile in my shoes", about the nuclear holocaust, about death and those who bury the dead, even about "The grave diggers on strike in New York". They sit motionless, but listening intently.

What is responsible for the changes? There are no simple answers, just as the one example may not be truly representative.

One possible reason advanced is that these young people, very intelligent and frequently very well informed, have had time to think and have used it to do just that. The necessities and luxuries of life have been amply provided by their parents who were so occupied amassing the products of an affluent society, that they did not realize the by-products they have also lavished upon their children.

There is no need, in an audience like this, to multiply examples, for just as the food we eat becomes a part of our bodies, so too do the sights, sounds, thoughts, values and customs of our society become a part of us, that is, if they have been seen, or heard. Just as we choose the food from the menu in front of us, or from the supermarket, if we live on one side of the Atlantic, or from the green grocer, the butcher and the pastry shop, if we live on the other side, so too do we select from our environment, the mores, the art forms, the means of livelihood and other characteristics which our times offer.

Our selections have led Erich Fromm to describe man no longer as "homo sapiens" but as "homo consumens".

He decries the change that he states so succinctly, and attributes it to two principles which he says are programmed into our technetronic society. I quote, "The first principle is the maxim that something ought to be done, because it is technologically possible to do it." As he sees it, this principle leads to the dethronement of all other values, and technological development becomes the foundation of ethics.

The second principle is that of "maximal efficiency and output", which he states "leads as a consequence to the requirement for minimal individuality (4)". Fromm goes on to see these people, who are more easily manipulated people and who have become little more than punch cards, finding their identity in the corporation rather than in themselves.

These quotations happened to be at hand, and are but one representative from the babel of serious thinkers who are trying to attract our attention to the depersonalizing influence of the multitudinous stimuli with which we have been bombarded in the 1960's. What of the 1970's?

Having reminded ourselves that, given our wills and freedom to choose among the wares and ways offered, information has produced us, there can be little doubt that information will continue to mold us individually and nationally.

A recent article in the journal *Science* discussing the implications of the national aspects, suggests that we must be interested in technical information in the age in which we live. Robert Gilpin of Princeton University, in that article links technological strategies and national purpose, claiming that domestic and foreign development necessitate a new relationship. He acknowledges

that passions continue to rule the world but states, and I quote, "Nonetheless, to an unparalleled degree, economic and technical considerations will shape the ways in which political interests and conflicts seek their expression and work themselves out." To continue, he writes, and I quote, "In a world where nuclear weaponry, has inhibited the use of military power, and where social and economic demands play an inordinate role in political life, the choice, success, or failure of a nation's technological strategy will influence in large measure its place in the international pecking order and its capacity to solve its domestic problems" (5).

He sees three strategies in operation at the time of writing. The first is scientific and technological research and development across the broadest front as exemplified by the United States, the USSR and by France. The second is scientific and technical specialization, as adopted by Sweden, the Netherlands, Switzerland and increasingly by Britain. The third strategy is that implemented by West Germany and Japan, namely, the importation of technology. As we know, the pecking is already evident.

He does not single out scientific and technical information which knows no boundaries and which is not licensed. Germany and Japan are believed however, to have put a much larger percent of their research budget into scientific and technical information than the other so-called advanced countries.

As a matter of interest Genevieve C. Dean, a research fellow in the Science Policy Research Unit, University of Sussex, is following the course of Chairman Mao's self-reliance in research and development across the broad front and his attempts to prevent the bourgeois from retaining a monopoly on technical expertise. According to her, Mao is trying to equip the labour force with new technical skills and to rely on the innovative abilities of the skilled workers to generate technical progress (6). We may admire Mao's courage but question the degree of sophistication that can be achieved by this method during this century.

Each of us occupies a place in history during an exciting period of rapid change. Each belongs to a nation which employs one of the technological strategies indicated by Gilpin, (5) or is in process of changing from one strategy to another. We may each wish to retain or to better our respective personal positions and national positions. Possibly some of us may also have a more international or global view, wishing to share the good things we enjoy with those whom we consider to be less fortunate than ourselves. A forerunner of many good things and of much good is information.

Who are we? Whatever else we may be, we are an aggregate of habits, opinions, preferences and prejudices. One convenient habit is to group people into categories and to label them neatly. The people in some categories we admire and enjoy. We may not always agree with each other but we understand each other. We dislike people in categories with certain labels and prefer to ignore them. Ignoring some of them may prove costly, for they present a threat, about which we are unaware. The people in other categories are of little interest except when we require their skilled or unskilled services.

When there is a community of interest people form groups naturally. Communications between them is easy and as the community becomes established it provides protection from numerous distractions. It is useful, convenient and comfortable. Therein lies a danger. Unless steps are taken to go beyond this community, the members become unable to communicate with others and become unaware of the benefits of the interchange of ideas beyond their immediate specialty.

Those of you who have read Dr. von Karman's autobiography, "The Wind and Beyond", (7) may recall his account of a professor who had worked at the Universities of Berlin, and Aachen and at the Brooklyn Polytechnic Institute in the US. He had not been geographically isolated but he was a prisoner of his intellectual community. He had failed to bridge the communication gap with those capable of understanding or of implementing the results of his research. He then lamented when his colleagues, like Dr. von Karman, who were skilled in exposition, supplied the bridge and were frequently credited with his discoveries.

What of opinions? What kinds of information should be communicated and to what audiences? Sir Peter Medawar in his book, "Induction and Intuition in Scientific Thought", claims that scientific papers are a fraud (8). Professor John Ziman on the other hand claims that scientific papers play a key role in the closed self-validating system of the scientific community and are key contributors to the consensus of public knowledge (9).

In which form do we like to receive information? One prefers the written word to the spoken word, another prefers the latter. Presentations combining the visual and the auditory are used to great advantage in both the educational and the advertising worlds. International meetings where the members may not all have facility in the language of the speaker can be made more meaningful by supplementing the spoken word with visual presentations.

The method of presentation preferred may vary according to the use to be made of the information. Listening to a report of a new discovery and following the diagrams on a screen may be interesting and stimulating. However, if we wish to relate the discovery to work in which we are engaged, a written description will be preferred. We will require the quantitative data, the method by which they were obtained, also the conditions under which the data were derived, in order to be able to study and evaluate the results.

The type of information we want may be dictated by the place we occupy in the hierarchal structure of our organizations, rather than by taste or temperament. This varies all the way from the raw data through various states of analysis to possibly only the significance of the results to some application.

What of our prejudices? As we have indicated, all information must be weighed in relation to the conditions which produced it. The number of variables in a given situation tend to increase as we proceed from the physical inorganic world through to the organic world and on into the realm of personality making the scientific method increasingly difficult to apply. At various stages in the investigations we apply logic. We might do well to reflect on one definition of reason which states that reason is the logical manipulation of those facts which have sifted through our prejudices.

Be that as it may, and in spite of human failings a vast amount of recorded information has been accumulated and is accumulating at an ever-increasing and alarming rate. We are concerned chiefly with written information which has been subjected to referees, has been criticized by the scientific community, and has been modified as further investigation has brought new facts to light.

We are however much more than habits, opinions, preferences and prejudices. We have work to do. The scientists among us are interested in discovering new information and adding to the existing store of knowledge in their chosen fields. They spend their days and nights peering into microscopes or telescopes, watching the dials of instruments, verifying results, developing new techniques. Their motivation may be to satisfy their curiosities or to apply the information in the industrial, medical, social or business activities in their particular spheres. The engineers in contrast tend to be interested in information in the form of equations or other forms which they can put to work in the design of processes, products and structures. The managers may be interested in new materials, new concepts and new social climates which may affect their methods of managing, or of planning, or may change their procedures, processes or products.

We are also people with imaginations who enjoy the adventures of the mind and may occasionally have inspirations. What better stimulation is there than new facts, old facts in new frames of reference, and the interchange of ideas through interaction with the mass of recorded information or with those who have immersed themselves with specific aspects of the wonders of the universe and the complexity and delights of the people who inhabit this planet.

The prerequisite to such adventure is the ability to communicate, which includes the ability to listen. One thing that we can learn from the famous under-thirty age group is that they do listen and they do think. They may not listen to what the older generations say, nor be any more interested in the facts than we are, once their minds are made up, but they do listen. You may recall that in the case of music they listen through a high volume of sound. We too must learn to listen through a high volume of noise of all sorts, a constant din.

What then is information? Information is as varied as one individual is from another. It is the stimuli which are meaningful to individuals.

As mentioned earlier there is a vast amount of information already stored and that this age of great endeavour and rapid change is pouring it out at an ever-increasing rate. What effect does this vast amount of recorded knowledge have on us? Do we try to ignore it? Are we overawed by it? Or are we availing ourselves of its bounty?

It was interesting to learn recently from a review of J.G. Crowther's book, "Fifty Years of Science", (10) that the Industrial Revolution created a need for information which led to the formation of the "Society for the Diffusion of Useful Knowledge". It grew out of the desire on the part of the industrial workers to learn about the principles of the industrial processes they operated. That was some time during the mid to late 18th century. Let us too, at this point in the paper, confine our attention to what is useful information, that which is carefully written, scrutinized and published on subjects related to the work in which we are involved. It may have been first presented at meetings, then rewritten for publication in scientific, engineering, or business journals and eventually forms a paragraph or two in a book which someone has written after painstakingly gathering together and sifting through all the journal articles, on the subject on which he has chosen to write and possibly through the letters to the editor as well. Don't misunderstand me - not all non-fiction books follow that laborious path. There are many authors who rush into print because there are prizes to be won by so doing. They too serve a purpose.

When we think of books, we probably think of libraries with huge quantities of books, row after row, floor after floor. When we want a book we learn that there is a system by which these books are filed on the shelves. People (in Canada they are usually women) of various ages and temperaments are experts in locating the book you want, providing you give her the name of the author and the title of the book. If you are unable to give her that information she may suggest you look through the maze of the card catalogue or may introduce you to another librarian who will assist you to identify a book containing the information you are looking for.

This method has stood the test of time and hopefully will be with us a long time to come. However the amount and complexity of information has increased so drastically in both types of publication and in the breadth and the depth of subject content that librarians have had an increasingly difficult time to keep pace. Consequently they have had little time to face the challenges of finding new ways of solving their problems.

New ways of recording and of storing information have been sought and are being sought, not only by librarians but also by those in the market place who have products to sell which they think may assist in the solution of this mounting problem.

This is an age of impatiences, of great energy, of increasing speed and competition. The need to provide useful information from a greater and greater store, faster and faster is recognized by many. Millions of dollars are being spent on research and on applications in an attempt to meet the need.

The need is recognized at many levels of our society. On the 20th July this year, President Nixon signed an Act establishing a National Commission on Library and Information Science. At that time he said, I quote, "Libraries and information centres are among our most precious national resources. Americans of all walks of life look to these institutions when they wish to expand their knowledge and wisdom beyond their own life experiences. They look to them also for help and enrichment in more immediate concerns, from high school dropouts finding their own way back into learning to nuclear chemists retrieving sophisticated scientific materials from a computerized data bank" (11).

Carol Kirsh, market coordinator for the magazine *Executive* writes, I quote, "It is rapidly becoming clearer that knowledge per se must be regarded as the prime resource of nations and of industrial enterprises. Its management and use offers new challenges and responsibilities" (12). She sees information as being scientific and technical, quantitative and qualitative and relates each to uses in management, marketing and production.

Computers are being introduced as the answer to the problems in dealing with this resource. Networks of computers are envisaged and some are already operating in a modest way.

What many enthusiasts have forgotten is that a computer is only a very sophisticated tool. It requires understanding and skill to use. The skill has to be learned. Until recent years those who were skilled in the use of computers have not also been skilled in understanding the basics of information identification and organization where content is significant. Progress is slow and costly.

The problems presented are by no means solved. A whole new discipline has grown up in an attempt to deal adequately with the problems presented. Many have yet to be solved and traditional solutions have yet to be modified before the computer can be employed as successfully as we would like. Nor is the computer necessarily the answer to all problems.

The discipline engaged in this challenging area as most of you know, is called information science. Its adherents are trained in many disciplines but are becoming known as information scientists, information specialists and like names, most of which are not yet well defined.

They have felt the need to form a society as did the industrial workers two centuries earlier. One difference, at least, should be pointed out. The industrial workers could depend upon the scientists of their day to teach them the principles underlying the industrial operations. Information scientists on the other hand are busily studying and formulating the principles underlying information identification, organization and processing for purposes of retrieval. They are also dealing with the problems of introducing practical procedures to meet the needs of each user of information, with his or her human characteristics.

The task of information science is to provide information to individuals who may be thought of as driving along a crowded freeway. Just as a driver on the crowded freeway requires mirrors and windows to see where he has come from, what is behind

him, what is coming up along side of him, what is passing him and the road ahead, so too each of us needs to be able to refer to the knowledge that is behind us, the information that is being discovered, the information that is being applied and the information and applications that can see ahead, on our respective freeways. The principles and products that can meet these requirements of individuals can be considered to be the goal of information science.

Some of us may still be questioning the value of information. At one extreme there is the continual din of events sketchily recorded for their impact value on two of our five senses through radio and television. At the other extreme, there are the carefully documented, verified and statistically treated data derived from well controlled experiments. And what of the clutter of newspapers and magazines and the shelves of books. If we have taken the time to think, we may also question how much of the bustling activity of sights and sounds of the Western world are merely bustle. Then if our minds fly to "the third world" we are jolted when we realize that the din there, is the bray of a donkey or the chatter of the monkey. Pieces of printed matter are read by the young to their parents and passed from one to another as a most precious commodity. The activity in such areas is the daily listless plodding of a meager existence. Need we question the value of information further?

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USER NEEDS

by

Mr. John F. Stearns

Director Scientific & Technical Information Div.
NASA

SUMMARY

The question of user needs is examined from three viewpoints: what has been and is being done to determine actual user needs; the kinds of services now evolving to satisfy these needs; and possible further steps to improve both definition and satisfaction of these needs. Attention is given to general areas of bibliographic services, and to specific opportunities inherent in these services for the application of techniques and procedures that may provide potential users with easier access to a wider range of informational alternatives.

USER NEEDS

Throughout recorded human history, we have had what we today call "information systems." Whether they dealt with clay tablets or papyrus, vellum manuscripts or printed books, microfilm or computer tapes, their purpose has always been the same: to organize and store mankind's constantly expanding fund of recorded knowledge so that it can be found by those who need it.

The scope and complexity of this task has, obviously, grown with the expansion of man's knowledge, with his ability to record and reproduce information more rapidly and in different forms, and with the continued growth -- both in numbers and diversity -- of the audience demanding access to our stored wisdom.

Obviously, too, there have been changes in the character of the task. A library of old that contained a few hundred laboriously copied manuscripts, and served a tiny group of philosophical scholars, could -- and almost certainly did -- concentrate on assuring safe storage. The patrons of that library could take care of themselves, without detailed catalogs, classification schemes, or indexes.

A few hundred years later, with the explosive advent of the printed page, the picture altered. Safe storage was still a basic requirement, but organization became paramount. The librarian himself needed at least a classification system, to keep his thousands of books in coherent order, and indexes to help him guide patrons to the volumes they might want.

But until quite recently, the library remained a rather passive focal point of intellectual endeavor. If you sought knowledge, you went to the library; whether you found what you wanted was largely the result of your own skill in exploiting the library's collection, or in persuading the librarian to help you do so. The information system came first; the user came second, and very few cared who he was, what he sought, whether he ever found it, or how.

Today, engulfed as we are in a rising flood of information, much of it scientific and technical, that picture has changed completely. Every library, every document center, every information system is more concerned than ever before with who its users are, what their informational needs may be and -- most important -- how those needs may be satisfied most economically and effectively. An information system is no longer a passive repository. Through accession lists, announcement journals, or more advanced current-awareness services, efforts are made to inform users about new acquisitions. Searching tools -- manual or machine -- may be provided for both remote and on-site use, and more and more retrieval systems are coming into being for rapid identification of the documents a particular user may need.

Fundamental though these developments may seem, they represent only one facet of our efforts to meet the growing informational challenge -- a facet concerned with doing better, and faster, and more comprehensively the things libraries have always done: make documents available to readers. More basic changes are taking place in the document flow itself. Professional societies, operationally and economically swamped with papers meriting prompt publication, are reaching for new modes of publication and distribution. Information systems are seeking new ways of compressing or summarizing traditional papers, "repackaging" essential information in more useful forms. And new kinds of information services are coming into being: services which deal with scientific and technical data *per se*, without a documentary "carrier," or medium; and services which, like the information analysis centers of which you will hear more hereafter, extract essential information from many sources, documentary and other, to provide expert assistance to persons in specialized fields.

These changes and innovations are costing a significant outlay of manpower and money, nationally and internationally. It would be comforting to think that they are all based upon precise knowledge of who the users of our myriad information systems are; precise knowledge of exactly what needs we are trying to satisfy; and, perhaps most important, precise knowledge of the real value -- both economic and intellectual -- of the services provided. Unfortunately, we have no such precise knowledge. Despite countless surveys and studies, in many areas over many years, we are still groping toward both quantitative and qualitative definitions of the real "user needs" we are trying to satisfy. We have as yet no means of accurately measuring either the true success of our efforts or the worth of the services we provide.

This is not to suggest that the technical information profession is working in the dark, blindly trying to achieve unidentified goals. We know, in general, what must be done; we know, in a great many respects, how to do it. A variety of services, provided over many years, has given us a solid groundwork upon which to build more effective information systems, and a great many organizations -- my own in the National Aeronautics and Space Administration among them -- are doing just that. In the process, to an ever-increasing degree, we are finding new and better ways of overcoming the limitation I mentioned a moment ago: our lack of precise means of measuring our progress and our ignorance of the precise needs of our myriad users.

This ignorance attests not so much to the inadequacies of our analytic efforts to date as it does to the truly incredible diversity of the factors that require analysis. On one side of the vast problem are hundreds of thousands of scientists and engineers. Their needs -- or desires, which to them are frequently the same thing -- vary individually from field to field, from task to task, and even from day to day. On the other side of the complex lie millions of documents or other records, loosely and confusingly covering dozens of relatively major scientific areas, and scores or even hundreds of specialties, each of which may pose unique informational problems. And while a scientist or engineer may concentrate his efforts in a single specialty, his informational needs usually remain broadly cross-disciplinary; a microbiologist, for example, specializing in enzymatic analysis, may find vital information in a dozen other fields -- chemistry, physics, mathematics, or medicine, to name only a few.

Along with these two major aspects of the problem lie many additional complications: linguistic questions, both translational and semantic; questions of classification and indexing, which ideally should have a high degree of commonality but which, in practice, require endless variations; questions of format and form demanded by content, ranging from a textual document to the graphs and tables of the engineer, or to the scientific findings which may best be expressed in a computer printout.

From the user's viewpoint, still another complexity arises from the great diversity of systems, techniques, and bibliographic procedures which the information profession has devised in its continuing efforts to cope with his needs. In many cases, I suspect, we information specialists have tended to kill the poor user with kindness, giving him so many avenues to explore, in his search for all the information he wants, that he may not know which way to turn.

For several decades, the broad problem has been under examination from two closely related points of view. One focuses primarily on how well a given system or service meets -- or seems to meet -- the needs of its clientele. The second, more recently undertaken and more difficult, deals with overall effectiveness of information systems: effectiveness in terms of cost, adequacy, and real value of services provided.

We began with surveys that sought to determine user opinion of information services: which ones the users liked or disliked, what new ones they might like to see established, and so forth. Many such efforts -- in the view of pessimistic observers, all such efforts -- failed to establish actionable conclusions. By dealing, in general, only with known users, they largely ignored the significant question of why others did not use the services involved; and they relied upon unverified subjective opinion to an undesirable degree.

In recent years, a large subset of such surveys have concentrated upon retrieval services, for retrospective searches or current-awareness announcements. Here the principal emphasis has been on two factors: "relevance" and "recall." The first is the percentage of document citations held pertinent to a user's interest, the second is the percentage of documents cited out of the total pertinent contents in an information store. These studies have shed light on inadequacies in indexing and searching techniques, but have had little direct effect upon actual satisfaction of user needs.

Broader studies of user needs in a context of overall information system effectiveness, begun within the last few years, are still in process. Only now are we beginning to develop outlines and structures for meaningful examination of, and experiments with, the complex process of the transfer of knowledge from its originators to those who can apply it. These evolving outlines suggest that it may be several years before we have substantial results for even quantitative judgments of how well, or how poorly, we are meeting a user's true needs. The ultimate step -- qualitative evaluation of the costs and the benefits of our information services and systems -- is still farther in the future, and it may never be fully realized.

Even though we cannot prove that one information service is better or more valuable than another, however, we do know many things that can be done to improve upon present efforts. I propose to devote the rest of this paper to these practical improvements, first from the standpoint of general areas of service, and then with regard to questions of information systems that can provide such services. By "areas of service," I mean such traditional topics as acquisitions, announcement, retrieval and dissemination. By "improvements," I mean steps affording increased satisfaction of user needs and increasing economies in operations.

In acquisitions, we have a clear need for better definition of the scope of our technical information collections, the richly various information banks in which we try to store the world's knowledge. To the extent that we can achieve sharper delineation of the contents of these collections, we can alleviate or control the overlapping attention that the literature in many technical fields now receives, as well as the duplicative processing that now takes place. By so doing, we can concentrate the resources of particular information activities upon the most pertinent materials. This concentration, in turn, should permit sharper focus upon improved service to users. Perhaps even more important, in long-range terms, we can give much clearer advice to users on where to find particular materials or specialized services.

Another and far greater improvement in our acquisitions process is plainly beyond reach now, but should be kept in mind as a potential solution to many present problems. This step, which needs the cooperation of the entire scientific and technical information community, would require the evaluation of documents at their point of origin. Such a process, however idealized it may seem, would provide invaluable guidance to information services as to which documents should be acquired on a priority basis, which might be given lesser attention, or -- however repugnant the thought might be to the author -- ignored entirely. (As long as we're dreaming, we might as well consider the thought that expert evaluation at the source could dispose of many redundant or otherwise questionable papers, a "birth control" process that would do much to ease the lot of those who try to acquire technical information.)

This line of thinking leads inevitably to similar considerations regarding the announcement services that we have today. The same principles -- clearer delineations of subject scope, evaluation and ranking of items announced, and filtering out the superfluous -- apply equally to the ways we use to bring new materials to the attention of users. More progress has been made in this area.

To begin with, we have long had abstract journals to announce our new accessions, usually categorized and indexed to aid a user in scanning a large mass of material. More recently, the development of computerized permuted indexes has offered another user aid in identifying materials of interest -- either among new materials, in a current-awareness process, or among entire collections in retrospective searching.

Another major development, permitting far more specialized announcement of citations believed pertinent, is the SDI service, Selective Dissemination of Information. This is a truly user-oriented technique, as many of you know well. It permits definition of a personal field of interest, with as much precision as the indexing language involved allows, and thus provides announcements of only pertinent documents. Unfortunately, while much admired by users, the SDI technique has a serious drawback from the standpoint of the information-services manager: it is expensive, even for a small audience, and can become prohibitively so in large-scale application.

An outgrowth of the SDI technique, designed to permit broader service at lower cost, involves computer searching new accessions against a rather large number of highly specific topics. The specialized listings that result can be reproduced in large quantity and distributed, through libraries, to individual users who have selected one or more topics as representing their personal field of interest. (The example of this sort of service with which I am most familiar is the SCAN -- for Selected Current Aerospace Notices -- service developed by the National Aeronautics and Space Administration. A counterpart service is also offered by the European Space Research Organization, ESRO.)

Many other improvements, of course, are possible and necessary in our announcement mechanisms, but at least the advances I have cited point the way toward obvious goals: lower costs, greater speed, and greater flexibility to meet a wider variety of user requirements.

Just as computers have aided the announcement process, they have also vastly improved the means by which we retrieve, from large, heterogeneous masses of information, the items that relate most directly to a specific search requirement. So, too, have they indicated the way to still further improvements. Less than a dozen years ago, most literature searching was done through the traditional, time-consuming process of visually scanning catalog cards and indexes. Since that time we have moved to machine scanning of computer tapes, then to direct-access devices and inverted index files to speed the process, and most recently to on-line systems that enable a user to conduct his own interactive dialog with an information bank stored in a time-shared computer that can serve a whole network of remote terminals -- processing dozens of searches simultaneously.

I am proud to say, in passing, that the first such large-scale on-line technical information retrieval system to go into full operational use is the NASA/RECON system, named for the remote consoles that comprise the network. Through such terminals -- each with a cathode-ray tube, an input keyboard, and an ancillary teletypewriter -- scientists and engineers at all NASA research and flight centers across the United States can search the central computer store of more than 700,000 documents in College Park, Md. Of perhaps greater interest here is the fact that the same NASA/RECON system has been in operational use in Europe for the last year, linking the central ESRO computer in Darmstadt to a growing number of terminals in ESRO member nations.

Such on-line systems (RECON is only one of several now under development) offer tremendous advantages in speed: search results are available in minutes, instead of the days or even weeks once required. They offer tremendous advantages in flexibility: a user can search several indexes -- subject, author, corporate source, and others -- sequentially or simultaneously, either browsing through a file or concentrating on a known target. A search can be defined with remarkable exactitudes: what was reported by Dr. X on subject Y when he was working at Laboratory Z during 1967 and 1968? They even, surprisingly enough, offer advantages in operating economy over previous large-size computer tape systems.

But the advantages of on-line retrieval systems are equalled by the challenges they present. With the user in direct contact with the information system, and able to record his needs and reactions almost automatically, all aspects of the information-handling process are subjected to more critical scrutiny than ever before. As more organizations develop on-line capabilities, the opportunities for computer linkages between related services increase, nudging us constantly toward compatible processes and offering an individual user readier access to more resources.

The last of the service areas I mentioned was dissemination -- a term used in the broad sense of actually placing in the hands of the user the information he needs. Here, I think, while we have made considerable progress, we may have farther to go than in any other aspect. Here, as in other areas I have discussed, progress thus far has been largely in handling documents themselves, which is not really purveying the information they contain. In these terms, progress has been significant. We now have copying devices which can provide facsimile documents in large quantities, at high speed, and decreasing cost. We have microform equipment and techniques which -- while still far from perfect -- permit wider and less costly programs to place copies of documents in the hands of potential users, in the form of microfilm, microfiche, or their many variants. We are beginning to see and use new systems that place computer output directly on microfilm, greatly enhancing the computer as a printing device.

But all of these advances, like the others I have reviewed, have a common drawback from the user's standpoint: They are all designed to give him copies of documents that may contain the information he seeks. After that, it is still up to him to dig out the facts, the figures, the concepts he needs. And the more documents we give him, through better services from constantly expanding files, the harder that task becomes. In many technical fields, we have already passed the point of diminishing returns: if we gave a user all the documents that might contain information of value to him, he could not possibly scan them all and still have time for creative work.

So we still have a huge unsolved problem in our dissemination mechanisms -- a problem concerned not with how we disseminate, but what we disseminate -- if we are to avoid flooding, and eventually drowning, the poor user in a tidal wave of paper and film. In oversimplified terms, for the sake of belated brevity, I suggest that the answer lies in processes analogous to those of chemistry and physics: distillation, extraction, and conversion. These processes have long been in use, but they now need far more intensive and extensive application.

The distillation process I have in mind, for example, is nothing more than the steps which take the contents of hundreds of technical papers, compress them into a few state-of-the-art summaries, and eventually insert their worthwhile essence into a single textbook for future generations.

The extraction process, again, is little more than the long-known procedure of drawing factual data from a multitude of documentary sources, validating it as possible, and providing the data to users in relatively "pure" form -- either in handbooks or critical-table arrays, or in the form of direct, factual answers to questions that we now answer only with reference lists or stacks of documents.

The conversion process, by contrast, is comparatively new. It involves the identification of worthwhile material in some original form -- a technical report, a journal article, a set of engineering drawings, a computer program -- and presenting them in some other form more assimilable to broader groups of people in other technical fields. (In NASA, we refer to this as a "repackaging" process.)

If we can apply these processes in depth, across the spectrum of scientific and technical information, we may be able to reach the goal that many now dream of: a composite of systems that can provide documents to those who want them, and information per se to the hundreds of thousands of others who want only the distilled or extracted essence of today's technical knowledge.

None of the potential improvements I have discussed -- in acquisitions, announcement, retrieval, or dissemination -- touch directly upon the most important issue of all: How do we structure all of our existing and proposed information services and systems into an effective, overall framework? How do we decide, for example, where bibliographic services as such should prevail, and where we need information analysis centers or data centers? How do we link the resulting elements into coherent networks that overcome geographic, intellectual, and mechanical boundaries? How do we provide referral services that will guide a user to, and through, whatever networks we may create? How do we assure evaluative mechanisms that will, in turn, assure dynamic evaluation rather than static desuetude?

These questions, and many others implicit in the broad requirement for better organization of our total information resources, are under most active consideration throughout the scientific and technical world. It is as impossible to forecast the answers as it is to foresee the overall result. But, ending almost where I began, it is possible to identify the central criterion against which both answers and overall results must be judged: How well do they satisfy the users' needs?

SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION

by

H.A.Stolk

**National Aerospace Laboratory (NLR)
Amsterdam**

SUMMARY

In this paper attention is paid to the information environment, the information explosion, and the user and his behaviour. Informal channels and formal services for obtaining information are discussed. A short description is given of the problems in information retrieval.

SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION

H.A.Stolk

INTRODUCTION

To begin I would like to review briefly the various elements pertaining to the information environment (Fig.1)

The Generator's activities give rise to two products, i.e. Technical Information and Technology.

With regard to *Technical Information* it is useful to distinguish two sub-categories, namely Scientific Information and Engineering Data which can be defined as follows: *Scientific Information* is technical information which adds to the general body of knowledge about a natural phenomenon, material property, or a scientific or engineering discipline. It does not disclose a specific connection with, nor application to, the design, production, operation, or maintenance of an item of equipment. *Engineering data* are technical information obtained from design, development, manufacture, operation, maintenance and logistic activities and are used by the recipient to design, produce, operate or maintain equipment. For example, engineering data include design data, development data, production data, manufacturing data and maintenance data.

Technology may be defined as a combination of facts, skills and techniques drawn from science and engineering to achieve some useful technical goals. (Contrary to Technical Information which emerges as documents, technology is frequently stored in the heads of individuals or teams of individuals.)

Only part of the general body of scientific information is available to the public. A considerable part is withheld for reasons of national security or company interests; this so-called *Classified Information* is not freely disseminated and remains largely unpublished even when the reasons for the classification have long since lost their significance. Most of the *Unclassified Information* appears in printed form, e.g. as journal articles or as reports and thus reaches the user, either as a direct recipient of such documents or through the action of some formal service, as for example a documentation unit, or through an informal channel. Types of formal services and information channels will be discussed later on. Users in their turn often produce new information, becoming generators, thus closing the cycle.

Before considering the sources of information proper, it seems useful to pay a little more attention to the proliferation of the published literature and the behaviour of those who use it.

THE INFORMATION EXPLOSION

Everybody who has been engaged in science and engineering in the last two decades has noticed with more or less awe the ever increasing flood of literature and has wondered how to keep up-to-date in his particular speciality or subject field. This affluence of information, often called the information explosion, is no doubt a matter of great concern and concerted action is needed to determine how to cope with it.

However, there is no consensus of opinion that such an information explosion really exists. Those who believe it does, present figures to indicate its extent. According to Willenbrock¹, the number of technical pages published has been increasing at a rate of some 10% per year since World War II which means that the doubling time is less than eight years. Lord Mountbatten² observes "at the beginning of the nineteenth century the number of scientific journals and periodicals was about 100; in 1850 it was 1000; and by 1900 it had reached 10,000. Some estimates of the number at the present time go as high as 100,000. If this rate of growth remains constant it would give a figure in the neighbourhood of one million at the end of this century".

Others do not accept the theory of the overabundance of information. Licklider³ states "there are still quite a few individual scientists and engineers who say they think there is no problem. Some are foremost leaders of their fields for whom meetings, visits, and preprint exchanges have short-circuited the library network". Mantell⁴ seriously questions the exponential growth in technical literature. According to his estimates the growth of the number of scientists and engineers seems to be linear instead of exponential, and "an analysis of actual literary productivity applied to these estimates, fails to indicate anything like the volume of information other writers have predicted would occur".

In spite of these opposing views most authorities in the information field accept that there is a profusion of information and suggest ways to control it. To handle the information flood more effectively the methods used to select documents for inclusion into a system and the arrangements for processing the information they contain, should be improved³. Swanson suggests that the repackaging of information in the form of critical review articles, state-of-the-art reports, etc. be encouraged, which make it easier for scientists and engineers to keep up with their fields⁵.

THE USER AND HIS BEHAVIOUR

When we take a look at the general categories of audiences who use technical information we find that there are three major audiences – the general audience, the mission audience, and the technical management audience⁶.

Technical information used by the *general audience* is characterized by the fact that the generator of the information does not know who specifically will use the information or when. The secondary use of this information by the general audience may be for purposes totally different. The *mission audience* is characterized by a close coupling to the generator of the information. The mission audience could for example be the procurement organization for a new piece of military hardware. In this case the research and development people are well attuned to the information needs of the procurement people with the result that not only is the precise information needed displayed, but it is also displayed in a manner most meaningful to the user. This close coupling between the generator and user results in efficient information transfer. However, we often find that the information tends to stay within the relatively narrow confines of the generator-mission user environment although it could be of considerable use to the general audience or other mission audiences. Finally we have the *technical management audience*. The increasing expenditures on research and development along with the additional complexity of the efforts themselves have increased emphasis on timely and accurate technical management information systems. Such a system has been developed in the US Department of Defense. This automated system was primarily designed to meet a management need to tell what work is being done, by whom and in very abbreviated form what the progress is. It has been found, however, that over half of the users are working engineers and scientists who use the system to identify on-going research and technology efforts related to their particular areas of interest. While the technical information content is minimal, it is normally sufficient to determine whether the performer should be contacted for detailed information.

Having defined the different categories of users we will now try to analyze their behaviour. One of the main features in this connection is the indifference of scientists and technologists toward the use of information centres and libraries, which belong to the group of formal systems.

The non-user problem is perhaps best demonstrated in two reports on user studies performed for the US Department of Defense by the Auerbach Corporation and North American Aviation, Autonetics Division respectively. These studies indicate that 5% of DOD personnel and 10% of US defence industry personnel use libraries as a first source of information and 0.04% respectively 1.30% use formal DOD information centres as a first source.

This indifference to information centres and libraries is by some authorities attributed to the fact that the formal systems fall short of meeting the actual needs of technologists or engineers. Technical people need engineering type information (performance characteristics, test data, etc.), items which the formal systems can hardly provide because they have not been organised for this purpose.

Another reason might be that scientists and engineers have never learned to use libraries and information systems in the most efficient way, irrespective of whether or not our present formal systems are the best way of transferring knowledge.

In connection with libraries this point is illustrated in the Parry Report which states that on a sample drawn from twenty three different British Universities, only 37% of undergraduates know what abstract services are, only 14% have been taught to use them, 25% do not know that their library has an author or subject catalogue, and 41% do not know that there is an inter-library loan service. Figures like these seem to indicate that users are in urgent need of some kind of training in the use of libraries and information services.

Another important feature is that most users like to have their information needs met instantaneously. What frequently happens is that the user makes a quick minimum effort at getting information. If the optimum information is not found during this first try, he will too often resort to the use of readily available but less than optimum information. For example, an engineer selecting materials may not use a low cost material because he cannot readily determine its characteristics in a particular environment. Instead he picks an expensive alloy which he knows will do the job. This gives rise to one of the frequently used arguments against expending resources to provide better technical information systems – the users seem to do their job without them! However the real question is: "How could their performance be improved by instituting better technical information systems?"

As most users are indifferent to the formal information systems, how do they obtain their information then? This brings us to the discussion of the informal channels, channels meaning the methods or procedures by which the information is acquired.

INFORMAL CHANNELS

One of the most important channels is the scientist's or engineer's own work team. It is attuned to his problems, it knows what he does not need to be told and thus it can provide him with optimum information through conversation. The significance of the workteam in information transfer is quantitatively illustrated in the Auerbach and North American Aviation studies, mentioned before. These show that the user turns to a colleague as a first source of information; the local work environment accounts for 60% of first sources for DOD users and 51% for Defence Industry users; external first sources amounted to 12 and 20% respectively.

The user within his work team has been intensively studied by Allan and his co-workers of MIT^{7,8}. A feature of these studies is the use of matched pairs of research projects — two or more teams working on the same project. Allan found that the literature is much less used by engineers than by scientists. The average engineer derives only 10% of the information which helps to solve or solves his problem from the literature (books, professional, technical and trade journals, etc.). The rest he obtains through such channels as *vendors* (representatives of, or documentation generated by suppliers of design components), the *customer* (representatives of, or documentation generated by the government agency for which the project is performed), *external sources* (paid and unpaid consultants and government agencies other than the customer agency), *technical staff* (engineers and scientists in the laboratory who are not assigned directly to the project being considered) and *company research* (any other project performed previously or simultaneously in the laboratory). The performance of these channels, i.e. their potential to generate the solution, is highest for company research, technical staff and external sources (so called expert sources).

Allan also found that in R and D laboratories some individuals are preferred by their colleagues for technical discussion and as sources or potential sources of information. Such individuals act as so-called *technological gate keepers*, a sort of internal consultant. In comparison with their colleagues they have greater contact with people outside of the organization and are more exposed to the technical literature. These gatekeepers allow the effective entry of information into the organization and also aid its dissemination within the organization.

Another channel, which is more used by scientists than technologists, is the so-called *invisible college*⁹, i.e. a group of scientists who know each other and share information directly. They keep track of one another's work through visits, seminars and small invitational conferences, supplemented by informal exchange of written material long before it reaches archival publication. Technologists keep abreast of their field by close association with co-workers in their own organisations. They are limited in forming invisible colleges by the imposition of organisational barriers¹⁰.

The importance of informal channels, some of which have just been indicated, has been brought to light by behavioural studies. It is therefore important to make more and more use of behavioural science in developing new information systems.

FORMAL INFORMATION TRANSFER

The printed page is still the most widely used medium for the publication and dissemination of scientific and technical information. It reaches the user in the form of journals, conference proceedings and reports.

Kessler describes the *journal* as "the most successful and ubiquitous carrier of scientific information in the entire history of science". As a result of the progress that is being made in the field of computerised information systems, the future of the journal has become a topic of lively discussion¹¹.

Journals depend to a large extent on papers presented at conferences. As these papers are in many cases published shortly thereafter in the *conference proceedings*, many journal articles are thus already a second written presentation.

With respect to the currency of information presented at conferences, the results of some surveys indicate that 40-70% of all authors had made oral or written reports of their work prior to the conference¹². In such a case the journal article becomes a third presentation of the same work.

The growing backlog many journals are faced with enhances the feeling that the journal is more and more becoming a late type of communication.

Publishers are quite aware though of the weaknesses of the present journal system and are increasing their efforts to make improvements (better quality, better selection, more specialisation, etc.).

Possible changes are constrained, however, by the fact that the journal is not only used by scientists and engineers but also by a lot of other people such as technical writers, educators, journalists, etc. Therefore we cannot do without it at present.

The *report* as a form of scientific and technical communication has come into prominence since World War II, largely as a result of government agency requirements for reporting of the work they have funded. The major problem in connection with the report literature is that a great part of it is inaccessible due to security classification and commercial considerations. This problem will be discussed later when we consider the function of defence documentation centres.

Based on the above described, so called primary literature, a number of secondary services have developed such as abstracting and indexing services, documentation centres, special libraries, current awareness services, etc. In the following sections we will concentrate on the more characteristic members of this group of formal information sources.

ABSTRACTING AND INDEXING SERVICES

These are organisations that collect world wide published literature in a specific subject field for the purpose of preparing indexes and abstracts thereof, and disseminating these in journals or on magnetic tapes. Typical examples are Chemical Abstracts, International Aerospace Abstracts, Engineering Index, etc.

Abstracting and indexing are techniques for constructing reduced representations of documents.

The abstract is composed of complete sentences summarising the content of a document or indicating what the document is about.

Indexing is achieved by allocating an appropriate set of terms (descriptors) to a document, enabling it to be retrieved. If index terms are freely selected their number soon becomes large and unwieldy, therefore some form of control has to be imposed. This has led to the construction of various types of vocabularies, of which the *thesaurus* (Fig.2) is currently the most widely used (e.g. the NASA Thesaurus, the EJC Thesaurus, Euratom's Nuclear Thesaurus, etc.). The thesaurus has cross references (e.g. broader term, narrower term, related term, use, used for, see, see also) to show the relationships among terms; it further has scope notes that describe the meaning and limits of a term, and it shows hierarchical arrangements between terms.

Indexing is still performed manually and the advent of the computer has hardly changed this practice, notwithstanding all the efforts which have or are being made to develop methods of automatic indexing.

The aid of computers is extremely useful, however, in carrying out purely clerical tasks and several indexes have resulted from this capability, such as permuted title indexes and citation indexes.

The usual approach in permuted title indexing is to keypunch the title, authors and bibliographic references. These items are then processed by a computer with all significant words in the title serving as indexing points which are listed in alphabetical order. The title reappears as many times in the index as there are significant words in the title. Such indexes are generally called *keyword-in-context* or KWIC indexes (Fig.3). Another system to be mentioned here is the *keyword-out-of-context* or KWOC index, whereby the significant word or keyword is taken out of the title, listed on the left hand side and followed by the title.

A *citation index* consists of a set of bibliographic references, each followed by a list of all those documents which include the given cited document as a reference^{1,3}. In essence, this index brings the researcher forward in time by listing those recently published documents referring to one of interest to him. The leader in this field is the Science Citation Index of the Institute for Scientific Information (Fig.4).

Standard indexing and abstracting services, for several reasons, have always been reluctant to include reports in their systems and in the US separate abstracting and indexing literature has been developed by the government agencies to take care of them. In this connection the Scientific and Technical Aerospace Reports (STAR) and the United States Government Research and Development Reports (USGRDR) document announcement journals, published respectively by NASA and the National Technical Information Service (NTIS) of the US Department of Commerce should be mentioned.

SELECTIVE DISSEMINATION OF INFORMATION

The services described above all attempt to enable the user to keep up to date in his subject field and are therefore called current awareness services. Current awareness can also be provided on an individual basis, in which case it is called Selective Dissemination of Information (SDI). The fundamental element in selection is the comparison, by computer, of the index terms assigned to newly received documents with the index terms representing the individual's interest profile. As SDI is the topic of Lecture 5 it will not be discussed here any further.

SPECIAL LIBRARIES

Special libraries are almost exclusively concerned with the acquisition, storage and retrieval of the literature on a particular subject or groups of subjects. The functions of these libraries are to provide comprehensive, precise and timely recall of items in their collections, to systematically examine the literature received, to issue acquisition lists and to prepare special bibliographies.

DOCUMENTATION SERVICES

Groups which are to a greater or lesser extent engaged in the acquisition, storage, retrieval and dissemination of information are known under a great variety of names. For the sake of simplicity however they may as well be called documentation services. Their function may best be illustrated by giving a short description of the two major European representatives in this field namely the Space Documentation Service and the Euratom Centre for Information and Documentation.

The Space Documentation Service (SDS)

This service was set up by the European Space Research Organization (ESRO) and the European Launcher Development Organization (ELDO), in collaboration with Eurospace^{14,15}.

The basis of the system is an information exchange agreement between NASA and the European space organizations. NASA makes available to the European organizations its unclassified technical and scientific information, together with its complete documentation system. In return, ESRO and ELDO supply European publications for inclusion in the system.

This system includes the report literature announced in NASA's semimonthly Scientific and Technical Aerospace Reports (STAR) and the journal and conference literature announced in the International Aerospace Abstracts (IAA), published by the American Institute for Aeronautics and Astronautics. The subject field has been broken down into 34 categories which apart from aeronautics and spaceflight include the basic sciences, geosciences, biosciences, electronics, computers, instruments, etc.

SDS provides a reference service to answer specific queries from users, a current awareness service such as selective dissemination of information (SDI), standard profiles (SP), and reproduction services, all these at moderate costs.

Contrary to SDI the *standard profiles* service is an impersonal current awareness operation based on over 100 standard subjects of great common interest and carried out every month. The results of each search are printed in quantity and made available at a much lower rate than the personal SDI. An extension of the standard profile concept, called the *industrial topic service* (ITS) is currently being established. The ITS profiles are very carefully selected in order to produce search results which are of special interest in the industrial field.

The document reproduction service can supply copies of documents (in the form of hard copy or microfiche) announced in STAR. Copies of documents announced in IAA may be obtained from AIAA's European office in London. Since the number of references on the file has already exceeded 500,000 a highpower computer system (IBM 360/65 with IBM 2321 data cell drive), located at the European Space Operations Centre (ESOC) in Darmstadt, is used.

As the first in Europe SDS has implemented the NASA man-machine dialogue capability, called RECON (remote console), at its headquarters in Paris and at the European Space Technology Centre at Noordwijk (Netherlands) by means of which it is possible to interrogate directly the central file at Darmstadt. The possibilities of extending the RECON system to provide direct access to information centres in ESRO and ELDO Member States are being examined (Lecture 5, Figure 14).

A number of years ago an internal need developed within ESTEC to store and retrieve test data on electronic components and materials. In common with any organisation having to specify components of high reliability, ESTEC was building up a collection of such information. It soon became evident that, in view of the quantity of data involved, and its rate of growth, a computer system would be required. A feasibility study showed that such a system was possible, and that moreover there would be industrial interest in such a *databank* on electronic components if its scope were slightly extended to incorporate not only test data but also manufacturers' data on components. The system design has already been completed and the trial phase has started. If the results of the trial are successful, the service will become publicly available alongside the existing services.

The Euratom Centre for Information and Documentation (CID)

This service operates the Euratom Computer-Aided Nuclear Documentation System¹⁶. The system of course gives full coverage to all those scientific fields in which Euratom is actively engaged, in particular reactor technology

and neutronics. Marginal and related fields covered include the basic sciences, biology and medicine, the geosciences, engineering and instrumentation, metallurgy and ceramics, etc.

For reasons of economy and efficiency the CID elected to use generally only the existing abstracts of nuclear documents as a basis for its computerized system. Some forty "secondary" data sources were selected and are now methodically scanned (foremost the US semimonthly "Nuclear Science Abstracts", which alone covers about 50% of the world's nuclear literature). The abstracts are represented by index terms chosen from the Euratom thesaurus, a vocabulary list of some 12,000 terms.

The selection of documents to be fed into the system is done by engineers, physicists, chemists etc. working daily in various Euratom research centres; engineers and scientists are better qualified than anyone to weigh the need of users of the system and to decide how useful a published document is and whether it should be fed into the system or not.

Rapid encoding of the selected documents enables the computer to ascertain automatically whether they have been analyzed previously. Likewise the task of analyzing the selected documents and indexing them by means of keywords chosen from the Euratom thesaurus (an average of 15 per abstract) is also entrusted to experts who received appropriate training to that effect. The abstracts published in "Nuclear Science Abstracts" are indexed in the US by that periodical's own team, under an agreement concluded between Euratom and the US Atomic Energy Commission.

The CID provides two kinds of service namely ad hoc retrospective literature searches in answer to specific questions and selective dissemination of information. The user receives photocopies of the abstracts pin-pointed by the computer.

INFORMATION ANALYSIS CENTRES

Information Analysis Centres, that were first established in the USA, can be defined as organisations directed toward the collection of technical information and data in a specific area of effort and its evaluation and filtering into a form of condensed data, summaries or state-of-the-art reports (Lecture 6). They are one of the major devices that have emerged in the search for means to transfer information faster, more efficiently, and more effectively to its ultimate user. Their importance is such that next week this Panel is holding a one day specialist meeting in Amsterdam on the subject. It is hoped that this will lead to a survey or study to determine whether IAC's are needed in Europe in a particular scientific or technical area. It is believed that the protection of the environment is one of today's most important issues and therefore the possibilities of implementing such centres in the field of air pollution and of marine pollution will be considered at the meeting mentioned above.

REFERRAL SERVICES

Their function is to direct individuals or organisations to specialised sources of scientific and technical information which are capable of meeting their specific need.

DEFENCE DOCUMENTATION CENTRES

The task of these centres in a NATO country is to announce and supply to the country's scientists and engineers the unpublished and sometimes published literature in their field. They mainly handle and control report literature which has been classified for national security reasons or has had a limitation placed upon its distribution for other reasons (proprietary rights, patents). The centres also accomplish primary distribution of technical reports from certain foreign countries to defence and related organizations.

It should be pointed out that the use of the services of the Defence Documentation Centres is governed by the so-called "need-to-know" principle. This principle implies that dissemination of classified information orally, in writing, or by any other means, is limited to those persons whose official duties require knowledge or possession thereof.

PROBLEMS IN INFORMATION RETRIEVAL

To finish this lecture the problems in information retrieval will be reviewed briefly. The diversity of uses and the time differential create serious problems in effectively retrieving and employing the information. This retrieval problem is growing more difficult as the degree of technological sophistication increases.

The primary difficulty is that the technical documents are written in relation to a specific end goal which was the basic objective of the work. Frequently this end goal involves a highly complex piece of equipment which

involves a multitude of discrete innovations all of which are combined to produce the end goal. The degree to which each discrete innovation is documented is highly dependent on the importance attached by the generator in relation to the end goal.

This creates two difficulties. First is the ability to index each discrete piece of technology so that the report can be retrieved when a user requests the information. The operator of the information storage and retrieval system is faced with the classic dilemma. If he employs a large number of index terms, searches will produce a great number of documents, many of which are not particularly relevant to the user's needs. On the other hand, too few terms will result in many relevant documents going unidentified.

The second difficulty resulting from end goal oriented technical reports is that frequently there is not enough information related to a specific technology for the general audience user to effectively take advantage of the past work.

Engineering type information consisting of design information, test data, operational data, manufacturer's part and component information and the like, is the most difficult to handle in a technical information system.

One aspect of the problem is that engineering information is difficult to capture so that it can be incorporated in an information system. The difficulty stems from both the amount of information being generated and the fact that most of it is being created for the mission audience which is not particularly motivated to disseminate it to the general audience.

However, the more serious problem with engineering information is that it tends to have a short half life. In other words what may be valid up-to-date engineering information today may be obsolete tomorrow. The cost of maintaining quality control over short half life engineering information is very high and soon gives rise to serious questions of the costs versus benefits.

The provision of technical information to the user locally has been the traditional role of the technical library. The difficulties are manifold. To begin with, they deal in documents - not information. The user must research the documents and extract that information which is pertinent to his needs. Nothing can discourage a user more than loading him up with a vast amount of documents of no interest. Also the technical libraries find it increasingly difficult to maintain collections covering the full range of the interests of the users they serve.

Finally there is a communication problem between the technical user and the non-technical librarian. This latter point is particularly significant and if our libraries are to become a viable part of our technical information system of the future, they must employ technically competent personnel in addition to those solely concerned with storage and retrieval of documents. These technically competent personnel not only provide an effective coupling between the user and the information source, but can also answer user's queries with highly relevant information - not just documents.

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Recommended Reading

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ITEM NO	DESCRIPTION	DATE	AMOUNT	STATUS	REMARKS
1001
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Source index

Fig. 4 Science citation index

Citation Index

CAPACITORS	VARIABLE AND DIELECTRIC	01822
	VARIABLE CAPACITORS AND TRIMMERS	00389
DISCRETE	VARIABLE METHODS IN ORDINARY DIFFERENTIAL EQUATIONS	01982
	VARIABLE RESISTORS AND POTENTIOMETERS	00388
RECTORS	VARIABLE WIRE WOUND	01638
FUNCTIONS OF A COMPLEX	VARIABLE WITH APPLICATIONS	02188
FUNCTIONS OF COMPLEX	VARIABLES	02237
COMPLEX	VARIABLES AND THE LAPLACE TRANSFORM FOR ENGINEERS	01223
ABLES FOR INSPECTION BY	VARIABLES FOR PERCENT DEFECTIVE SAMPLING PROCEDURE	01381
MEASUREMENT OF FREQUENCY	VARIATION IN "M"	00891
G AIR DRYING CURDLATING	VARNISH FOR ELECTRICAL PURPOSES - FIBROXIN	00895
	VARNISHED COTTON CLOTH SHEET AND TAPS	00874
ELEMENTARY	VECTOR ANALYSIS WITH APPLICATION TO GEOMETRY AND	01193
SYMBOLS FOR HEATING AND	VENTILATING INSTALLATIONS GRAPHICAL SYMBOLS FOR	00837
	VERNER HEIGHT GALGES	00837
MECHANICS OF	VIBRATION	01231
DICTIONARY OF TERMS USED IN	VIBRATION AND SHOCK TESTING - CL	02288
SHOCK AND	VIBRATION IN LINEAR SYSTEMS	01663
	VIBRATION PROBLEMS IN ENGINEERING	00301
00385	VACUUM DEPOSITION OF THIN FILMS	
	WILLIAMS L	
	CHAPMAN AND HALL LTD	PP 50 1958
00386	VACUUM TUBE AMPLIFIERS	
	TALLEY GE	
	A	
	WALLMAN M	
	MCGRAW HILL BOOK CO INC	PP 740 1962
00389	VARIABLE CAPACITORS AND TRIMMERS	
	DUNNEN GMA	
	PITMAN AND SONS LTD	PP 189 1957
00390	VARIABLE RESISTORS AND POTENTIOMETERS	
	DUNNEN GMA	
	PITMAN AND SONS LTD	PP 178 1956
00391	VIBRATION PROBLEMS IN ENGINEERING	
	TRUSSARDI S	
	D VAN NOSTRAND CO INC	PP 467 1955

Fig. 3 Principle of KWIC indexing

SELECTIVE DISSEMINATION OF INFORMATION

A System Review

by

S. C. Schuler

Head of Ministry of Technology's
Reports Centre for Science and Technology, U.K.

SUMMARY

There is an information problem for scientists and technologists because the amount of literature is large and growing rapidly.

Selectivity is, therefore, an essential factor in the transfer of information and the Selective Dissemination of Information (SDI) is a technique for providing individual users or groups of users with announcements of a limited number of documents specifically of interest to them.

For large systems, selection of relevant documents is achieved by a computer program which compares a file of bibliographic data on current reports, journal articles, etc., with the interest profile of the SDI user. The selected references can be provided to the user in card form (useful for filing) or as a computer printed listing containing the main document bibliographic data, descriptor terms and, in some cases, a short abstract.

A review is made of various automated systems which have developed in North America and Europe during recent years. Some experiences of both large and small SDI systems are discussed and detailed aspects such as profile construction, cost benefits and economics, and user surveys are considered. As an alternative to printed output an outline is given of a system using on-line access to a central information store enabling the user to have selected references displayed visually at his remote console.

SELECTIVE DISSEMINATION OF INFORMATION

A System Review

S. C. Schuler

1 INTRODUCTION

Why do scientists and engineers need information? Mainly for one of two reasons:-

- a To keep up to date with the latest results of work being done by fellow researchers in their field ("current awareness").
- b To obtain a detailed retrospective review of what has been achieved to date in a particular field, especially when embarking on a new assignment.

It is with problems involved in the first, "current awareness" that I am mainly concerned in this review.

It is well known that the world output of scientific and technical information is increasing rapidly and is said to be doubling in volume every 8-10 years. It is estimated that more than one million scientific and technical papers now appear each year in reports, journals, conference proceedings and other publications.

Most of you will have already encountered something of this problem in your own working environment.

Increasingly the scientist or engineer today has to subdivide his field of interest and to specialise in narrower subject fields. Furthermore his working time has not increased, indeed his effective time as a professional has decreased in some instances because of the load of administrative procedures and accounting methods essential in modern management operations. He has less spare time to browse through the literature and information bulletins and librarians must arrange wherever possible for individuals to receive only those publications which match their specialist needs. Selectivity is clearly an important factor in the transfer of information and the selective dissemination of information (SDI) is a current awareness technique for providing individual users with announcements of a limited number of documents specifically of interest to them.

A number of organisations both in the United States and Europe have successful SDI systems in operation. Their experience is reported in the extensive literature on the subject and a selected reading list is given in the Appendix. In this review the experiences of three main organisations are described: the National Aeronautics and Space Administration who have been active in the SDI field for many years, the IEE/INSPEC programme and the ESRO/ELDO Space Documentation Service (SDS).

2 MANUAL CURRENT AWARENESS

Current awareness services are not new; many libraries in research organisations and in industry operate current awareness services of one kind or another. These may include the selective distribution of periodicals, the publication of information bulletins categorised to draw attention to various subject interest fields or the provision of a personal notification of items of interest to individuals. In the latter case the subject interests of users are recorded and the information staff, when scanning the incoming literature, use these records to match users' interests to documentary input. The usefulness of these methods may be limited however by inconsistent selection or by excessive volume of material announced. There are other limitations. When the number of users per information officer exceeds a certain value it becomes a very formidable task to consult the card file each time a new article or report is scanned. The optimum number of users per information officer will depend on the nature of the subject field, the variations between users and the skill and experience of the information staff, but it is probably less than one hundred and could be as low as twenty or thirty. To provide an effective service when the ratio is higher than this is usually considered to be beyond the capabilities of a purely manual system and some form of automation is essential. Fortunately, however, scientific research is accompanied by the emergence of new technology and the advent of semiconductor devices has produced very significant advances in the development of computers with the capability of storage and fast retrieval from large banks of technical information.

3 SDI PRINCIPLES

The aim of SDI is to provide a regular alerting service on selected subjects, defined by the user, to newly published reports, journal articles, patents and other documents having a high probability of interest to the user. The basic element in modern SDI services is the matching, by computer, of two data files, as shown in Fig. 1. One is the bibliographic data file of new documents, the document profile. This file includes terms describing the subject content of the document (descriptors) and other details of the document such as the author, corporate source, etc. The other file contains the user's subject interest or search profile.

The computer will compare these two profiles and print out references to documents whose profiles match the search profile. These references are then sent to the user.

Other important elements of an SDI system are the type of presentation used for the selected announcements and a mechanism for obtaining feedback from the user to indicate his degree of satisfaction with the announcements he has been sent and the correctness of his profile.

4 THE BIBLIOGRAPHIC DATA FILE AND INPUT PROCESSES

Some of the larger documentation centres have built up extensive computer data files. NASA already has in its central computer system data on some 500,000 documents in the aerospace field and adds to this at the rate of 20,000 new items per year. Inputting of documents to a system involves an examination of the document by a skilled subject analyst for relevance, the detailing of the bibliographic data, preparation of an abstract or expanded title and the allocation of descriptor terms controlled by a thesaurus. These descriptor terms serve also in the SDI matching operation. After verification and editing, the document record is keypunched onto paper tape or direct to magnetic tape for input to the computer. As an example of what is involved the flow process for report literature at my own Centre is shown in Fig. 2.

The processing of documents in this way is an expensive operation and is usually only appropriate to large scale national or international services. A local information centre wishing to set up an SDI service can however purchase a data base of bibliographic information already processed and available on magnetic tape, from a number of organisations. Four such services are listed in Table 1. These services are at various stages of development; CAS first provided tapes in 1962, MEDLARS following in 1964 and INSPEC starting in 1969.

Service	Source	Publication providing data base
CAS (Chemical Abstracts Service)	American Chemical Society	Chemical Abstracts Chemical Titles Chemical-Biological Activities Polymer Science and Technology CA Condensates
INSPEC (Information Service in Physics Electrotechnology and Control)	Institution of Electrical Engineers, UK	Computer and Control Abstracts Electronic and Electrical Abstracts Physics Abstracts
MEDLAPS (Medical Literature Analysis and Retrieval Services)	National Library of Medicine, USA	Index Medicus
USGRDR (US Government Research and Development Reports)	Clearinghouse for Federal Scientific and Technical Information, USA	USGRDR Semi monthly journal

Table 1: Computer Tapes Services

Each magnetic tape has its own format developed to meet the system requirements of the originators. Different tape formats raise problems for the purchasing organisation and special computer systems programs usually have to be compiled to enable searching and retrieval to be carried out.

As a result of INSPEC involvement in UK and international standards work it was possible for this service to adopt, at a very early stage, the draft format for communication of bibliographic records proposed by the International Standards Organisation (ISO/TC46). During 1969, conversion programs were written for the INSPEC implementation of this standard and specimen tapes were made available to a number of potential users. From the beginning of 1970, the INSPEC tape services have been available on a regular production bases, under the names INTAPE 1 and INTAPE 2. INTAPE 1 is a fortnightly or monthly service, which includes the complete bibliographic record with abstract, and which is provided in subsets corresponding to the IEE abstract journals. INTAPE 2 is a fortnightly service, without abstracts, which is provided only as a single integrated service. In 1969 80,000 records of journal papers, conference proceedings, books, patents and reports were entered into the INSPEC data bank; in 1970 more than 110,000 will be added.

There will inevitably be some subject fields where no organisation is known to supply input tapes covering precisely what is required with the minimum of extraneous material. For example in the field of plasma physics, controlled fusion research, superconductors and high vacuum technology the U.K. Atomic Energy Authority's Culham Laboratory decided that they would need to generate their own information bank to serve locally some 200 users. An interesting account of their approach is given in ref. (1). To minimise the task it was decided to use only titles as input to the system and to match on these alone for SDI with the proviso that additional descriptors could be added in the small number of cases where the title appeared to be inadequate. A short experimental period with the SDI service showed that a reasonably effective service could

be obtained from title matching and the system has now been operational for several years.

The Royal Institute of Technology in Stockholm operates an SDI service for research workers in Sweden. The Institute initially purchased tapes from five external organisations but found the mechanical engineering field insufficiently covered and therefore decided to produce their own in-house data base in this subject field. Gluchowicz (2) gives a valuable account of their experiences.

5 THE ROLE OF THE THESAURUS

Descriptor terms play an important role in document indexing and SDI processes. Ambiguity in terminology can be a severe barrier to efficient information retrieval.

Each specific area of technology usually generates its own specialised vocabulary or even 'jargon' to express the concepts peculiar to its own interests. Examination of these specialised vocabularies reveals that many terms thought to be unique are clearly related to terms used in other areas of technology. A thesaurus shows these relationships and permits the selection of terms that will improve communication both within and across the boundaries of science and technology.

A thesaurus is essential for reference by those directly responsible for indexing and retrieval of technical information but ideally it should also be used at every step along the line of information flow. This may involve any or all of the following: author, editor, indexer, abstractor, librarian and the user of information.

A highly developed Thesaurus of Engineering and Scientific Terms (TEST) was originally published by the US Dept. of Defense as AD 672,000. It is also available as an Engineer's Joint Council Publication with the same title in a printed version on sale at \$36 and on magnetic tape at \$500. TEST is an outstanding achievement and represents the completion of a major effort by the US Engineering Joint Council and the Dept. of Defense. A feature of the TEST thesaurus is the many points of access provided to enable a user to locate the term required. TEST is arranged in four main sections: Part 1 is the main list of Descriptors arranged alphabetically followed by a Permuted Index, a Subject Category Index and a Hierarchical Index. Examples of Entries and Notations are shown in Fig. 3. Organisations who wish to construct their own detailed vocabularies, perhaps less extensive in scope but more intensive in detail, will find that TEST provides a useful starting point.

Another valuable Vocabulary should be mentioned - the NASA Thesaurus (NASA SD-7073). The subject items listed in this publication were chosen on the basis of their significance and use in the aerospace field.

Similarly the European Atomic Energy Community (Euratom) have their own Special Thesaurus EUR 500.e.

The concepts and arrangements of these vocabularies are similar to TEST.

6 SUBJECT INTEREST PROFILE

Formulation and modification of a user's Subject Interest Profile is of prime importance in the SDI system and demand considerable effort from the user and the system operators. The profile is not just a short paragraph describing the user's interests although this may be the starting point provided by the user. It is a rational set of specific terms in the same technical language as that used by the document analysts. Structuring an interest profile requires considerable skill and a good deal of imagination and intelligence as well.

Clague (3) in a review of the IEE Electronics SDI services describes some of the main factors involved in profile building. Users were each asked to supply details of their information requirements in narrative form on a standard sheet (this was found to give a clearer view of their interests than a mere list of subject terms). On the reverse of the sheet additional information on terminology was requested together with details of references to articles found relevant to the user's work.

From this information a list of concepts of interest to the user was drawn up and these were converted into the standard indexing terms or descriptors listed in the IEE Thesaurus. The construction of the latter is similar to that of TEST. A practical example of using the thesaurus in profile building is shown in Fig. 4. Under "Crystal Defects" there is the instruction conveyed by the abbreviation UF that this is to be "used for" "lattice defects". The information that "Defects" is a term of broader meaning is conveyed by BT (broader term), whereas "Dislocations" has a narrower meaning indicated by NT (narrower term), and "Crystal lattices" is shown to be a related concept by RT (related term). Similarly, under "Lattice defects" there is an instruction to use "Crystal defects" in its place.

Once the concepts mentioned or implied in the user statement have been translated via the thesaurus into a list of standard descriptors, these form the basis of a draft subject profile.

An example of a draft profile is shown in Fig. 5. It is in three sections, the first contains the number and name and address of the user. (DIRECT indicates that notifications are to go direct to the user rather than via an intermediary. In the latter case the name and address of such a person would be shown). The next section lists the descriptors which cover the user's interests and finally we have the Boolean logic statement showing the relationships between the descriptors. The plus signs are logical OR, the full stops are logical AND, and the brackets have their usual algebraic significance. Logical NOT, denoted by a minus sign, can also be used in the logic statement, but is not represented here.

Thus in the example, the user is interested in ionisation, breakdown and discharge phenomena in gases. The Boolean statement is therefore in two basic parts, the first main bracket specifying the physical phenomena, and the second main bracket the gases of interest. The profile indicates that the user is interested in any document dealing with any of the phenomena (descriptors 1 to 11) in any of the gases (descriptors 11 to 25).

The size and complexity of the profiles varies very widely, depending on whether the user has general interests in one subject area, or whether he has specific interests in a number of basically unconnected areas. In the latter case a very complex profile containing 100 descriptors or more may be necessary to define his individual requirements. The average profile would contain about fifty terms.

The effectiveness of the search profile is to a high degree dependent on the active interest of the user. The user is more able to influence the effectiveness of his search profile if he knows the basic principles of the computer-operated information retrieval system and profile construction technique. The value of two-day seminars with lectures and exercises in profile construction for users is stressed by Gluchowicz (2).

7 ANNOUNCEMENT FORMS

Various methods have been devised by SDI system operators for announcing selected documents to users. There are currently two main types of presentation; the card type of announcement and the reproduced paper copy of the computer print-out.

7.1 CARD FORMAT

Several SDI services provide the user with a card for each selected announcement. The INSPEC SDI Service provides a computer-produced print-out for each subscriber showing his name and address and the serial numbers of the documents which match his profile. The print-out is sent out in duplicate - one copy is for the user to mark to show the relevance of the items announced and to return to INSPEC. This print-out is accompanied by a set of 5 inch x 3 inch cards giving bibliographic details of the document together with the relevant descriptors. An example is shown in Fig. 6. A survey by the IEE had shown that users preferred cards to computer print-out. A more sophisticated tab type card was used during NASA's first SDI programme, which was operational from December 1963 to January 1966. This provided the user with two cards for each announcement (Fig. 7). One was an EDP card which was punched and interpreted with the user's name and address and the document number. This card contained small prescored boxes which the user could press out to express his evaluation of the announcement; i. e. that the announced document was (a) of interest and that a copy was wanted, (b) was of interest but that no copy was wanted at the moment, or (c) was not of interest. The second card was not computer manipulated, although it was cut to the same size and shape as the typical computer punched card. It presented the full offset-printed abstract of the selected document. The two cards for an announcement were inserted into a single window envelope with the user's name and address visible. As the envelopes were necessarily in order by the abstract number, they were then manually sorted according to the user's organisation for batch mailing and subsequently by the organisation's mail room for internal distribution. This particular NASA SDI service has been terminated in favour of Group SDI described in para. 10.

Cards are usually popular with the user, since he may file those of particular interest in a personal desk-drawer file. Undoubtedly, this is a valuable facility for many scientists and engineers, but, maintaining an individual file, either of cards or documents, can be expensive in terms of the individual's time and possibly in storage space.

7.2 COMPUTER PRINT CUT

Computer printed listing of the selected document references are generally less expensive to provide than card type notifications. The listings usually present only the main bibliographic data plus subject descriptors although some SDI services do provide a shortened form of abstract in addition. Fig. 8 shows a typical ESRO/ELDO SDI print out. The computer run is monthly. A notification is also sent when no matching citations are produced.

For the NASA SDI system three-copy (no carbon required form) is used. The computer-printed bibliographic data appear on all three sheets, together with the user's name and address. The computer also prints small boxes opposite each announcement for the user to tick when checking the relevance of the announcement sent to him.

8 USER FEEDBACK

Having formulated the user profile a feedback mechanism is required to monitor how well the SDI System is meeting the aim of informing the user of the maximum number of relevant documents with the minimum number of irrelevant items. Figure 9 shows a representation of the performance of an SDI system devised by Clague (3) and some of the faults that arise in it. The 'noise' (i.e. non-relevant documents notified to users) can fairly readily be measured by asking users to mark and return a duplicate copy of the notifications to show which were relevant and which were not. Users of the INSPEC service are asked to mark the notifications with a 1, 2 or x to show whether a document is:

- 1 of high relevance, i.e. the user would expect to be notified of all such documents.
- 2 of some relevance, i.e. the user would be happy if such documents were notified to him but would not be concerned if a proportion were not.
- (x) of no relevance, i.e. he would not wish to be notified of such documents.

The other fault, that of 'misses', however, is more difficult to quantify, since for this it is necessary to discover which of all the documents in each week's input are relevant to each user. In the exploratory stages of setting up the INSPEC service each user received periodically a list of all those sections of the week's total accessions which were at all likely to contain relevant articles, and the user was asked to mark those he considered relevant. The computer printed out all the documents for the week, arranged in the subject groups to which each document had been assigned. The user's annotation of the lists was then compared with his SDI notifications for that week. This enabled a figure to be calculated for the percentages of misses. From analysis of the misses and noise, modifications could be made to improve the overall performance of each search profile. The flow chart in Fig.10 shows aspects of profile construction and how the feedback mechanisms are integrated.

9 SDI SERVICES AND COSTS

The costs of SDI services will depend on various factors including input volume, computer processing, materials used, titles or abstracts, profile maintenance etc. For example the use of abstracts in SDI announcements will cause an increase in costs both in computer time and print-out.

Penner (4) has made a valuable survey of charging policies for a wide range of information services including SDI. Two examples of current services and their costs are given below.

9.1 INSPEC SDI SERVICE

An experimental SDI service in the field of electronics has been operated for almost two years. During 1969, weekly SDI notifications were provided free of charge to a statistically selected group of electronics research workers, drawn equally from government establishments, universities and industry, in return for their assistance in evaluating the service. At the beginning of 1970, the service was made generally available on a subscription basis (£45 per year) but was still confined to electronics. The response has been most encouraging, and, from the beginning of 1971 the SDI service will be fully integrated with the main IEE journal production system, and will be offered across the whole subject range of the INSPEC data base, i.e. Physics, Electrotechnology, Computers and Control.

9.2 ESRO/ELDO SDI SERVICES

The basis of the Space Documentation Service operated by ESRO/ELDO is an information exchange agreement between NASA and the European Space Organisation. NASA makes available its unclassified scientific and technical information on magnetic tape to ESRO/ELDO; in return ESRO/ELDO supply European publications for input into the NASA system. The SDI service is a monthly computer print-out for any aerospace topic required by the user. Each month some 7,000 new items are scanned and the references in STAR and AIAA are selected which relate to the user's particular area of interest. The SDI service costs F 168 to ESRO/ELDO member states' institutes and F 460 to industry (per profile).

10 GROUP SDI OR STANDARD PROFILES

In addition to SDI services tailored to the needs of an individual there are similar but much cheaper group SDI or standard profile services which meet the requirements of a group of people with similar subject interests.

Standard Profiles are much less expensive than SDI due to the transfer of much of the overall effort from the computer operations and profile refinement activities to the traditional and cheaper operations of printing and sorting.

10.1 NASA/SCAN

A very successful example of a Standard Profile Service is the NASA/SCAN. Selected Current Aerospace Notices (SCAN) are issued twice monthly to scientists and engineers serving NASA and its contractors. Every second week, a computer searches the latest reports received by the NASA Scientific and Technical Information Facility and journals received by the Institute of Aeronautics and Astronautics for references pertinent to about 200 topics. New topics are added as the need arises and items in little demand are retired or merged. Bibliographic details and descriptors for relevant documents are printed out in NASA/SCAN Notifications. These are duplicated and sent to several hundreds of organisations where librarians distribute them to individuals registered to receive this service. A portion of a typical notification is shown in Fig. 11.

Each person receives only notifications of new findings in the technical areas in which he has expressed interest. To obtain a report or article listed in a notification, he need merely mark that item, write his name and location on the notification, and send it back to his local librarian for the supply of the documents.

As an illustration of the flexibility of the present NASA/SCAN service, topics include Supersonic Transport, Clear Air Turbulence, and Aircraft Noise and Sonic Boom. The latter two topics provide the user who has these very specific interests with only the announcements he wishes to see, while the Supersonic Transports topic provides a much broader range of coverage. This flexibility extends throughout the SCAN topics, which can overlap in coverage and can announce the same document under a number of appropriate headings, permitting the user to match his specific or broad interests by a minimum of notification listings.

The SCAN listings are prepared by offset reproduction of the computer print-out and are then sorted into batches and sent to the participating organisations for their individual users. Thus the sorting effort is distributed, with the local participating organisation having the responsibility for maintaining user records and sorting and distributing each issue.

User reactions are important but there is no provision for constant feedback as in SDI. Brief questionnaires are sent out to users at intervals and data are sought on the relevance of announcements, comments on the need for new topics or combining several existing ones, or splitting one with too broad a coverage. This arrangement works well and provides adequate feedback for modifying the current lists of SCAN profiles.

Services like SCAN have pioneered the Standard Profile technique and provide a selective subject announcements service to very large numbers of users. Costs lie in the range of \$10 to \$20 per user per annum.

10.2 ESRO/ELDO (SP)

The ESRO/ELDO Space Documentation Service provides a "Standard Profile" (SP) system based on 111 different standard subject topics and involves a computer search each month. The results of each search (some 7,000 documents are added to the computer tape each month) are printed in quantity and made available to member states on a sliding charge scale - F84 for 1 to 5 topics to F60 for 21 to 25 topics per topic per year. An example of an SP is shown in Fig. 12.

10.3 INSPEC GROUP SDI

The INSPEC Group SDI Services in Electronics operates on the basis that the requirement of a project group research and development team are submitted by one member who acts as Group Co-ordinator and who receives and distributes the output. Two copies of the output are provided for £65 per year - additional cost for each copy above two - £8 per year.

10.4 INNOVATION SERVICES

A further variant of the Standard Profile concept is the Innovation announcement services such as NASA/Tech Brief and Mintech-Techlink.

Techlink is a service for the communication of technical information and ideas to those in UK industry concerned with design, applied research and development. Its aim is to stimulate fruitful innovation by providing a flow of information about new technical developments selected as being relevant to a company's products and processes.

Techlink draws on new scientific and technical knowledge which is not widely publicised or accessible through other media.

The main sources of material available through the service are:-

- i the results of research, development and experimentation by UK Government establishments, and especially 'know-how' which may have wider industrial applications;
- ii foreign technological information;
- iii work by the UK Research Associations which merits bringing to a wider audience than their members;
- iv selected inventions available for licensing from the National Research Development Corporation.

Each Techlink deals with a single topic, summarised in a single page leaflet, which is classified under one or more of 52 subject headings and despatched to recipients who have asked to receive the particular subject codes. Sometimes the information contained in the Techlink is complete in itself. It is, however, always written to give the reader enough detail to decide whether to pursue the idea further and wherever appropriate a source of follow up information is given. Fig. 13 is a typical Techlink - the Subject codes in the top right hand corner indicate (6) Bonding and Joining (29) Materials Testing (42) Protective Coatings. Techlinks are also used to draw attention to report literature such as bibliographies, tables of basic data etc. which might be useful in industry.

Initially intending users are asked to provide a profile of their technological interests by selection from the fifty-two subject headings and in this way are alerted only to ideas and innovations likely to be relevant to their interests. The Techlink information is designed for direct use by the recipient. Copies are supplied to more than one person in a firm, each person covering his particular field of interest by appropriate selection of subject codes. Subject Classified Indexes are also available.

The Techlink Service has now been operating experimentally for two years and some 530 individual Techlinks have been published. There are nearly 5,000 individuals in UK industry receiving this service.

11 DIRECT ACCESS TECHNIQUES

Finally in this review of SDI Systems we arrive at the latest development in automatic information transfer whereby the user can have direct access to the information files in the computer by personal use of a remote on-line video terminal. Among the first organisations to develop such a system was the Lockheed Aircraft Company and about the same time NASA had begun to specify similar requirements. A contract between NASA and Lockheed led to the successful implementation of the RECON (REmote CONsole) system in 1969. The operations by NASA in the USA enable users at individual research units in different parts of the country to interrogate the data files at the main NASA centre at College Park near Washington, DC. A similar system recently described by Isotta (5) has been installed by ESRO/ELDO using the computer at the ESRO Operations Centre at Darmstadt and connected by line to remote terminals at the ESRO SDS HQ in Paris, the ESTEC establishment in the Netherlands and the Mintech Reports Centre at St. Mary Cray, Kent. The capacity of the system to handle terminals is much greater than the three mentioned and developments envisaged are shown in Fig. 14 which indicates the possibilities of a European network.

The Darmstadt data base is provided with magnetic tapes by NASA under an exchange agreement with ESRO/ELDO.

The basic equipment elements of a terminal are shown in Fig. 15, and consist of a video display, a keyboard, and a small teleprinter. Additionally a small control unit, which acts as a buffer memory between the computer and the user, and a modem are required. The keyboard enables the user to communicate direct in plain language with the computer. The computer's response is displayed in printed words on the screen. The teleprinter provides a print out of the end result of the search, usually a list of report citations.

11.1 SEARCH ROUTINE

The user's first action is to press the "Begin Search" key and Fig. 16a shows the computer asking a number of routine questions such as title of search, name of searcher, etc. The information given in reply serves to identify the subsequent output. The VDU display at various stages of a search is shown in Fig. 16a, b, c and d reproduced from ref. (5). The user first selects from the NASA Thesaurus the Subject Terms or Descriptors which he thinks will produce relevant documents - in this case DIFFUSION, CENTRIFUGES, SEPARATORS, URANIUM AND ISOTOPES. He then interrogates the computer for additional related terms to be suggested. This is done by pressing the "Expand" command key and first asking for an expansion of the word DIFFUSION, since useful documents might have been indexed under terms containing this word. As shown in Fig. 16b the computer responds by displaying on the terminal screen the word DIFFUSION (labelled E06) together with other related terms in alphabetical order. The heading CIT is the number of document references

(CITATIONS) in the system against the word chosen. DIFFUSION is seen to have 6088 citations. As no other terms in the general area of DIFFUSION seem relevant, the next command would be to "SELECT E6" as a result registering the word DIFFUSION with 6088 references as set 1. The same procedure is followed with the remaining descriptors, CENTRIFUGES, SEPARATORS, URANIUM and ISOTOPES, which are registered as Sets 2, 3, 4 and 5. The user decides that he wishes the search to operate by taking Sets 1 or 2 or 3 each in combination with Sets 4 or 5, i.e. only reports which have been indexed under the terms DIFFUSION and URANIUM or DIFFUSION and ISOTOPES, etc. will be selected from the file of half a million document references. The next command is therefore "COMBINE SETS", a logical equation $(1+2+3)*(4+5)$ being keyed in. This step is itself given the reference Set 6. The command "DISPLAY SET HISTORY" shown in Fig. 16c shows Set 6 with a total of 125 references obtained as a result of combining Sets 1 to 5 by means of the logical equation. In Set 7 in the figure the effect of the command "LIMIT", in this case to references received in 1968 and 1969, may be seen. The 125 references have now been reduced to 12. In practice the command DISPLAY SET HISTORY is not often used, since the set history is normally simultaneously printed out on the telex attachment as the dialogue proceeds. In the next figure (Fig. 16d) the use of the DISPLAY command is shown. Each of the 12 references selected may be examined. The title of the report is followed by a mini-abstract or notation of content. If necessary each of the records can be inspected and some editing carried out using the command KEEP, before printing on the high speed printer (1200 lines/min.) The average time for a search is about 30 minutes.

The version of NASA/RECON now in use in ESRO does give the capability of searching on personal authors as well as subject terms. The name of the author may in fact be combined with the subject terms, just as if it were a term in the dictionary. Thus, in the example shown above, Set 6, which gave a total of 125 references, could be combined with "SMITH" as Set 7. The resulting output would then only be reports by "Smith" on the subject chosen. A similar capacity is being developed to enable searches to be made by corporate source as well.

12 LOOKING AHEAD

Many of the SDI Services currently available are in process of development. Some aspects which require attention and may possibly lead to more efficient services are:

- a Announcements to the user in the form of cards or computer print-outs are not ideal. Upper case computer print-out is not very readable and the use of upper and lower case format so that the text of computer print-out is more like letterpress printing is desirable.
- b Considerable extension of the use of remote on-line direct access terminals to computerised information systems is probable. This will enable an element of 'browsing' to be restored particularly to the scientist since he will be able to directly and quickly examine citations in a very narrow subject field.
- c With most SDI Services the user has to contact his Librarian to obtain the documents listed in the SDI announcement. The automatic dissemination with the SDI announcements of the cited reports in microfiche form is possible and might be adopted for some services.

Finally, I would like to leave you with a thought on recognising the value of information by the Vice President, Research & Engineering of the North American Rockwell Corporation. "The serious professional in research and engineering realises without being told that he has a need throughout his career for continually renewing his information and revitalizing his intellectual tools. Correspondingly executives at all levels are becoming increasingly aware that the most valuable asset of their organisation is not floor space, not machine tools, not laboratory space, but the breadth and depth of knowledge of the technical staff; the currency of their information and techniques and the effectiveness with which they relate these capabilities to the organisation's work programme".

I believe that the SDI Services I have outlined play an effective part in this information transfer process.

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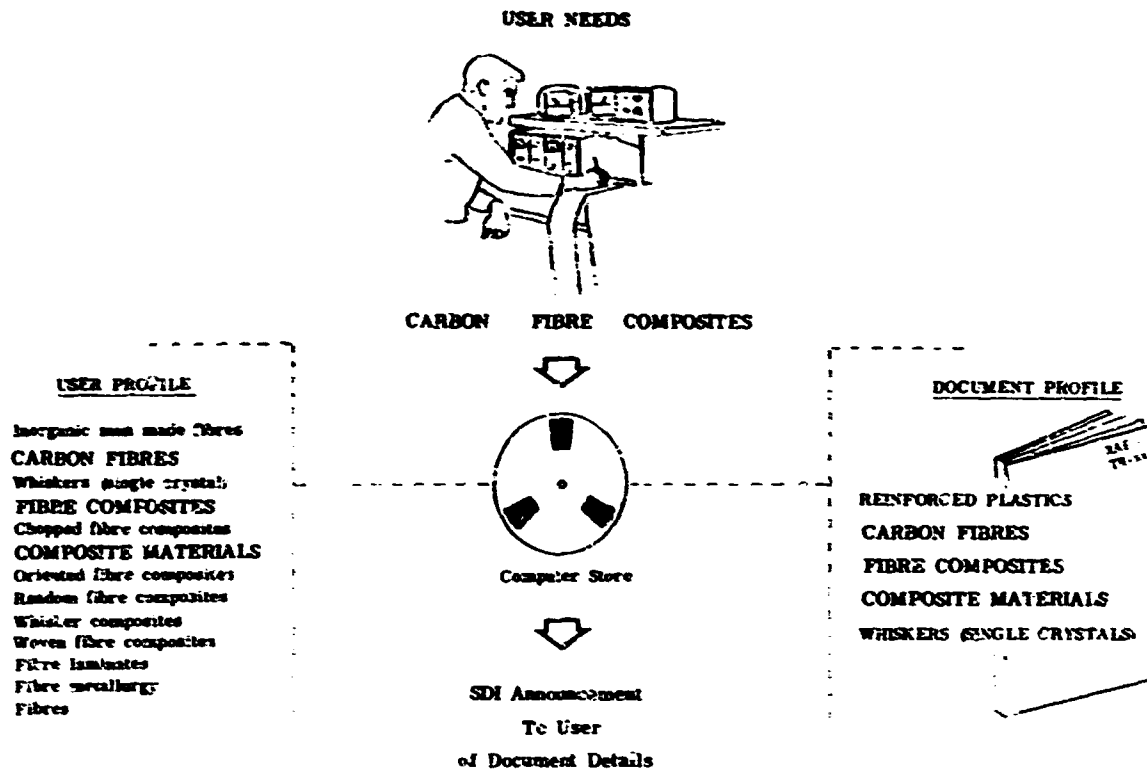


Fig. 1 SDI - How it works

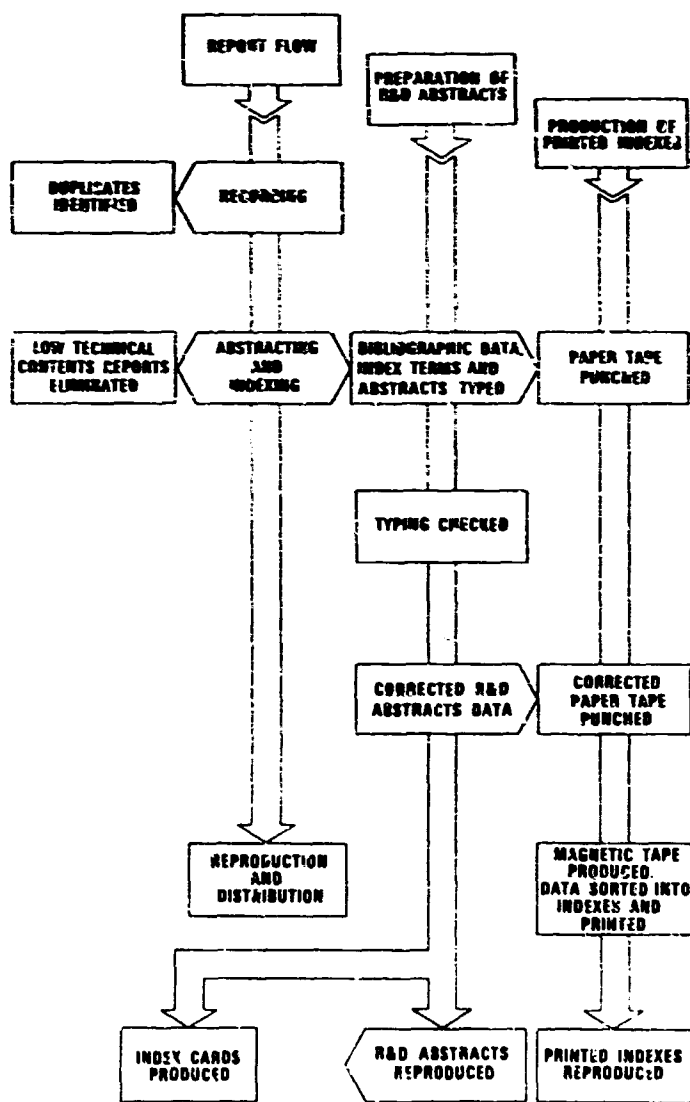


Fig. 2 Flow diagram for report processing

CRYSTAL DEFECTS

UF	Lattice defects
BT	Defects
NT	Dislocations
ICT	Crystal lattices

Lattice defects use Crystal defects

Fig. 4 Thesaurus terms for a profile

AU:16304: DR A.R.
 DEPT OF ELECTRICAL ENGINEERING AND ELECTRONICS THE
 UNIVERSITY BROWNLOW HILL LIVERPOOL 3;

DIRECT:

- 1: IONIZATION;
- 2: IONIZATION COEFFICIENTS;
- 3: DISCHARGES;
- 4: ARCS;
- 5: SPARKS;
- 6: GLOW DISCHARGES;
- 7: TOWNSEND DISCHARGES;
- 8: ELECTRON DETACHMENT;
- 9: ELECTRON ATTACHMENT;
- 10: ELECTRON SWARMS;
- 11: BREAKDOWN;
- 12: GASES;
- 13: AIR;
- 14: CARBON DIOXIDE;
- 15: OXYGEN;
- 16: INERT GASES;
- 17: HELIUM;
- 18: NEON;
- 19: ARGON;
- 20: KRYPTON;
- 21: XENON;
- 22: FLUOROCARBONS;
- 23: C5F8;
- 24: SULPHUR HEXAFLUORIDE;
- 25: NITROGEN;
- 26: SPARK GAPS;
- 27: RECOVERY;
- 28: PLASMA;
- 29: DECAY;

(1+2+3+4+5+6+7+8+9+10+11). (12+13+14+15+16+17+18+19+20+21+(22+23+24+25))+(26...+29)

Fig. 5 A draft user profile

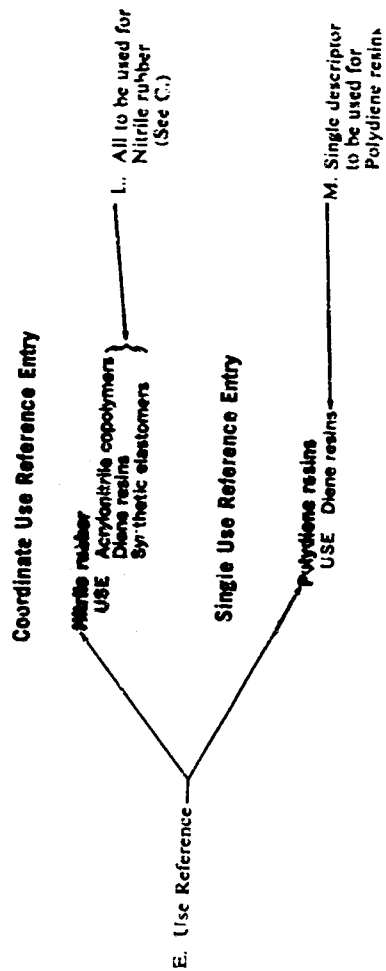
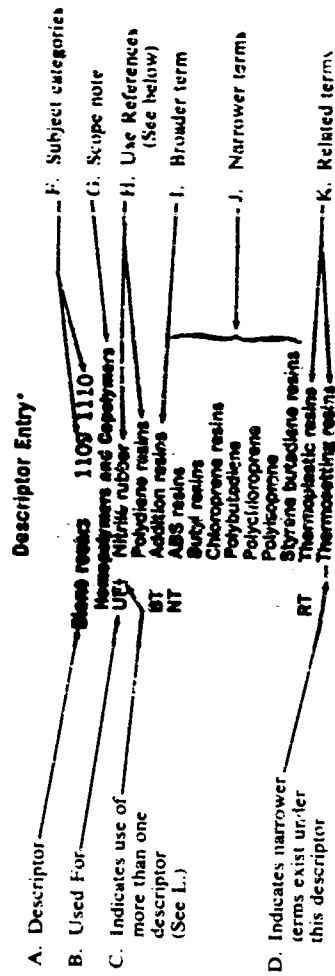


Fig. 3 Example of entries in the TEST Thesaurus

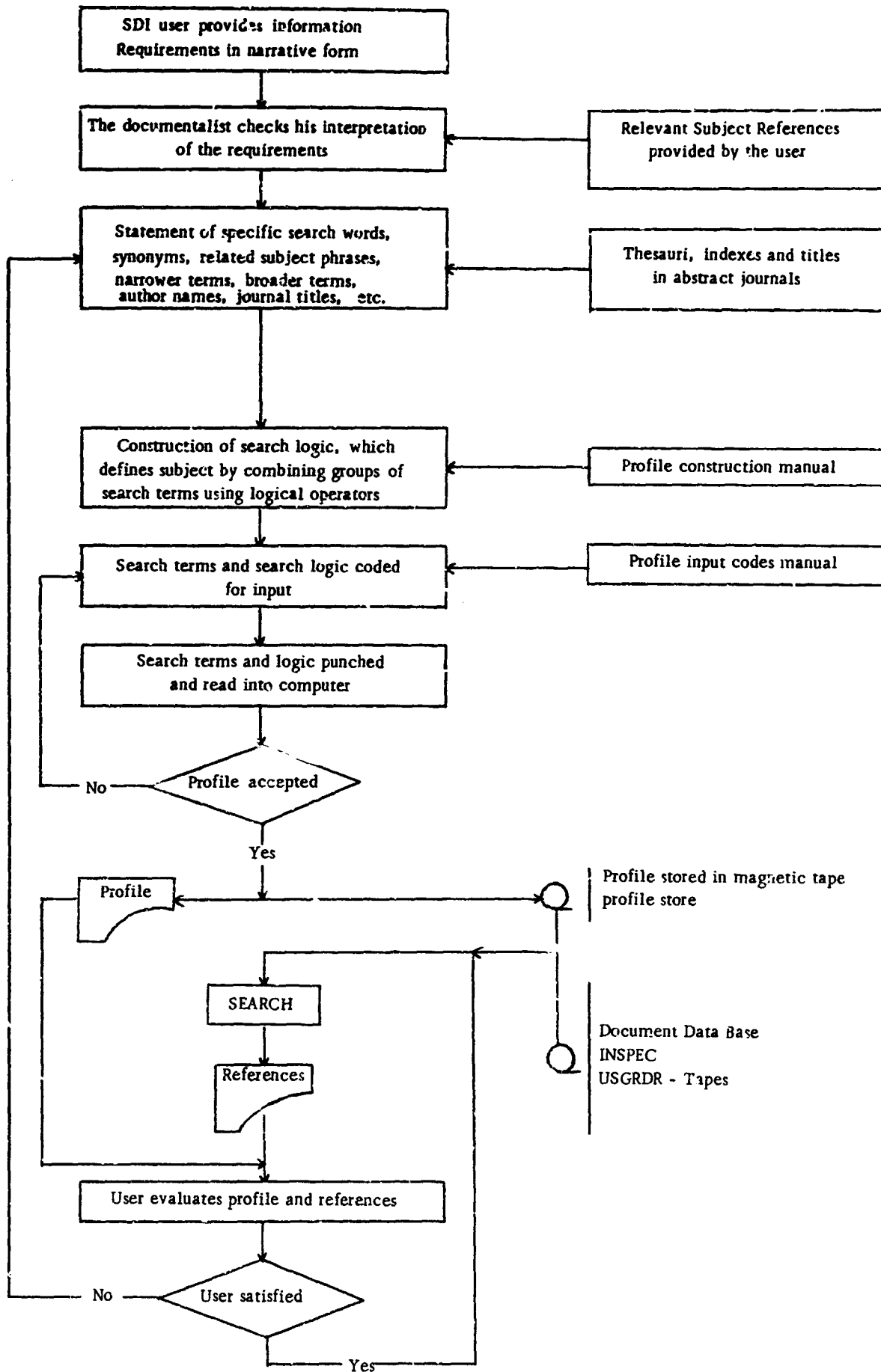


Fig. 10 Flow chart for SDI operations

NASA/SCAN Notification

03-04 HYDRAULIC AND PNEUMATIC SYSTEMS
142 AND STAR ISSUES 805, MARCH 1968

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03-04

NAME	MAIL CODE
MATHEMATICAL MODELS, *MOTORS, PNEUMATICS, STEP FUNCTIONS	C12 N68-13964*
EXPERIMENTAL TECHNIQUES FOR IMPEDANCE MEASUREMENTS OF SERVOCONTROLS DE MAVILLAND DIV., MAWKER SIDDELEY AVIATION, LTD., EDGWARE /ENGLAND/ HALL, J. C. INIT- IN ONERA AEROELASTICITY MANUAL, VOL. 4 019870 /SEE N68-14561 05-32/ COLL- 24 P	C32 N68-14565
AERODYNAMIC LOADS, *AERODYNAMIC STABILITY, AEROELASTICITY, *AILERONS, AIRCRAFT STRUCTURES, EQUATIONS OF MOTION, HYDRAULIC EQUIPMENT, *IMPEDANCE MEASUREMENTS, *SERVOCONTROL	
747 INCORPORATES PROVEN TECHNIQUES - NEW TECHNOLOGY. PLATTNER, C. M. PUBL- AVIATION WFER AND SPACE TECHNOLOGY, VOL. 87, DATE- NOV. 20, 1967, COLL- P. 82, 83, 87, 89, 92-94.	
AIR TRANSPORTATION, AIRCRAFT CONTROL, *AIRCRAFT DESIGN, *CARGO AIRCRAFT, HYDRAULIC EQUIPMENT, *PASSENGERS, *WEIGHT ANALYSIS, WING PROFILES	C02 A68-15916
A BISTABLE PNEUMATIC FLOW TRIGGER /PNEUMATYCZNY STYMULACYJNY PRZERZUTNIK DMUSTABILNYZ/. NICHALOWICZ, S. K. POLSKA AKADEMIA NAUK, INSTYTUT AUTOMATYKI, WARSZAWA, *POLAND PUBL- POZIARY, AUTOMATYKA, KONTROLA, VOL. 13, DATE- DEC. 1967, COLL- P. 552-555, 7 REFS. LANG- IN POLISH.	
ACTUATORS, *BISTABLE CIRCUITS, *FLOW RESISTANCE, *PNEUMATIC CIRCUITS, PNEUMATIC CONTROL, PNEUMATICS, PRESSURE EFFECTS, *TRIGGER CIRCUITS	C03 A68-16244 #
THREE-DIMENSIONAL FREE JETS. RAJARATNAM, M. SUBRAMANYA, K. ALBERTA, U., DEPT. OF CIVIL ENGINEERING, EDMONTON, ALBERTA, CANADA PUBL- ROYAL AERONAUTICAL SOCIETY, JOURNAL, VOL. 71, DATE- DEC. 1967, COLL- P. 858, 859, 7 REFS.	
*FLOW VELOCITY, *FREE JETS, *HYDRAULICS, JET FLOW, LENGTH, PREDICTIONS, *THREE DIMENSIONAL FLOW, VELOCITY DISTRIBUTION	C12 A68-16414
DC-9 ENVIRONMENTAL CONTROL DESIGN AND FIRST YEAR'S SERVICE EXPERIENCES. CLEEVE, V. F. HAUGER, H. M. PERLEE, J. S. McDONNELL DOUGLAS CORP., DOUGLAS AIRCRAFT CO., AIRCRAFT DIV., LONG BEACH, CALIF. CONF- /AMERICAN INST. OF AERONAUTICS AND ASTRONAUTICS, COMMERCIAL AIRCRAFT DESIGN AND OPERATION MEETING, LOS ANGELES, CALIF., JUN. 12-14, 1967./ PLAC- NEW YORK PUBL- JOURNAL OF AIRCRAFT, VOL. 5, DATE- JAN.-FEB. 1968, COLL- P. 54-72. REAN- *FOR ABSTRACT SEE ISSUE 15, PAGE 2423, ACCESSION NO. A67-303740 AIAA PAPER 67-407	
AIR CONDITIONING, *AIRCRAFT DESIGN, AIRCRAFT RELIABILITY, CABIN ATMOSPHERES, CONFERENCES, *DC 9 AIRCRAFT, *ENVIRONMENTAL CONTROL, PNEUMATIC CONTROL, PRESSURIZED CABINS, *SYSTEMS ENGINEERING	C03 A68-16602 #
APPARATUS FOR SEMI-AUTOMATIC MEASUREMENT OF THE LOGARITHMIC DECREMENT OF FREE VIBRATIONS OF GASTURBINE BLADES. DEVICHENSKII, N. P. FASITRITSKII, V. S. TITOV, F. M. INIT- IN- INTERNAL FRICTION IN METALS AND ALLOYS. EDITED BY V. S. POSTNIKOV, F. N. LAVADZE, AND L. K. GORDIENKO. TRAN- /TRANSLATION OF VNIITRENMEE TRENIÉ V METALLAH I SPLAVAKH, MOSCOW, IZDATEL'STVO NAUKA, 1966./ PLAC- NEW YORK, PUBL- CONSULTANTS BUREAU, DIV. OF PLENUM PUBLISHING CORP., DATE- 1967, COLL- P. 211-216.	
AUTOMATIC CONTROL, *FREE VIBRATION, GAS TURBINES, HYDRAULIC EQUIPMENT, LOGARITHMS, *MEASURING INSTRUMENTS, *TURBINE BLADES, *VIBRATION DAMPING	C14 A68-16622
HIGH ENERGY RATE FORMING OF FIBROUS COMPOSITES. ROBINSON, R. K. BATTELLE MEMORIAL INST., PACIFIC NORTHWEST LABS., RICHLAND, WASH. CONF- IN- FIBER-STRENGTHENED METALLIC COMPOSITES, AMERICAN SOCIETY FOR METALS, METALS CONGRESS, SYMPOSIUM, CHICAGO, ILL., NOV. 2, 3, 1966, PAPERS. 0608-16770 05-170 SPON- SYMPOSIUM SPONSORED BY THE AMERICAN SOCIETY FOR TESTING AND MATERIALS, AND THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. RESEARCH SPONSORED BY THE BATTELLE MEMORIAL INST. PLAC- PHILADELPHIA, PA., PUBL- AMERICAN SOCIETY FOR TESTING AND MATERIALS /ASME SPECIAL TECHNICAL PUBLICATION NO. 427/, DATE- 1967, COLL- P. 107-173, 5 REFS.	
ALUMINUM, ALUMINUM OXIDES, *COMPOSITE MATERIALS, CONFERENCES, *FABRICATION, *FORMING TECHNIQUES, HONEYCOMB STRUCTURES, PNEUMATIC EQUIPMENT, *REINFORCING FIBERS, STAINLESS STEELS, TITANIUM, TURBINE BLADES	C15 A68-16777
RESEARCH AND DEVELOPMENT OF ON-BOARD SYSTEMS AND ELEMENTS FOR AEROSPACE VEHICLES RESEARCH REPORT, PERIOD ENDING 30 SEP. 1967 PENNSYLVANIA STATE UNIV., UNIVERSITY PARK. SHEARER, J. L. DATE- OCT. 1967 COLL- 13 P REFS. NASA-CR-91679 RR-6	
*AEROSPACE ENGINEERING, DIGITAL COMPUTERS, FLUID AMPLIFIERS, FLUID JETS, FLUID TRANSMISSION LINES, *FLUIDICS, HYDRAULICS,	

Fig. 11 NASA/SCAN notification listing



SEARCH TITLE SPACE DOC. SERVICE 9060-01
 DATE/FILE 4-9-70/2
 SEARCH BY ESPC/ELDO, NEUILLY, FRANCE
 REQUESTOR 4
 ADDRESS 4

TERMINAL 02	4-9-70	TOTAL TIME	PFR	COMPAND	ON THIS USER	RECON	TIME	MIN	NO
RECON	000.02	1	COMBINE	000.01	1	PRINT	000.01	2	
RECON SEARCH	000.00	0	LIMIT	000.00	0	LIMIT ALL	000.00	0	
EXPAND	000.00	0	KEEP	000.00	0	END SEARCH	000.01	1	
DISPLAY	000.05	4	TYPE	000.00	0	ERADR	000.00	1	
DISPLAY SET	000.00	0	MESSAGE	000.00	0	ITEMS PRINTED			4

TOTAL ELAPSED TIME IS 000.17 MIN.

GENERAL COMMENTS (IF ANY)

SFT	NO.	DESCRIPTION
1	0	ENDFIRE ARRAYS
2	1	LINAR ARRAYS
3	5	PHASED ARRAYS
4	0	YAGI ANTENNAS
5	6	1+2+3+4

STANDARD PROFILES

No. 80

LINEAR AND PHASED ARRAYS

MARCH 1970

114, Avenue de Neuilly, 92-Neuilly-sur-Seine, Fr

Tel. 837-74-00

Telex. 82388

TON15412+ ISSUE 04 CATEGORY 09 00/07/69 UNCLASSIFIED REPORT
 SOLID-STATE DISPLAY (GALLIUM PHOSPHIDE PINNED ARRAY FOR SOLID STATE IMAGE SCAN AND DISPLAY)
 LYNEH, R. J.
 INTERNATIONAL BUSINESS MACHINES CORP., NEW YORK, (TU494474)
 INIT- IN AGARD DISPLAYS FOR COMMAND AND CONTROL CENTERS JUL. 1969 P 329-149 /SEE N70-15408 04-08/ COLL- REFS COPYRIGHT. AVAIL- CFSTI / REFERENCES/ DISPLAY DEVICES/ ELECTROLUMINESCENT/ GALLIUM ARSENIDES/ IMAGING TECHNIQUES/ JUNCTION DIODES/ LINEAR ARRAYS/ OPTICAL SCANNERS/ SOLID STATE DEVICES

TON15124+ ISSUE 04 CATEGORY 07 AD-695731 F:TC-MY-23-489-09 19/09/69 UNCLASSIFIED REPORT
 A NEW PRINCIPLE FOR CONSTRUCTION FOR FREQUENCY INDEPENDENT SHARPLY DIRECTIONAL ANTENNAS WITH ELECTRIC BEAM SCANNING (NARROW BEAM ANTENNAS WITH ELECTRIC BEAM SCANNING)
 ANDREWS, J. I.
 ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER, WASHINGTON, D. C. (AD617971)
 DATE- 19 SEP. 1967 COLL- 16 P REFS TRAN- TRAN SL. INTO ENGLISH FROM 12V. VCSIL UCHER. ZAVED., R AD. ELEKTRON. /USSR/ V. 11, NO. 5, 431968 P 45-475 AVAIL- CFSTI / AREAS (RADIATION/ DIRECTIONAL ANTENNAS/ ELECTRICAL PROPERTIES/ ELECTRONIC EQUIPMENT/ PHASED ARRAYS/ RADAR SCANNING

TON14436+ ISSUE 04 CATEGORY 07 AD-693999 SU-SFL-6 9-047 QSR-32 NINA-225/59/ 11/04/69 UNCLASSIFIED REPORT
 ELECTRONIC RESEARCH PROGRAM IN NONCOMMUNICATION NAVAL ELECTRONICS TECHNIQUES QUARTERLY STATUS REPORT: MAR. - 31 MAY 1969 (NONCOMMUNICATION NAVAL ELECTRONICS TECHNIQUES FOR PRECISION INTERPULSE INTERVAL ACQUISITION AND TRACKING AND FOR SELF-ADJUSTING VOLTAGE FILTERS TO ADAPTIVE SIGNAL SORTING)
 RAMMO, W. R.
 STANFORD UNIV., CALIF. (S0380476)
 STANFORD ELECTRONICS LAB. DATE- 31 MAY 1969 COLL- 29 P REFS AVAIL- CFSTI / AREAS (DIRECTION/ DATA ACQUISITION/ ELECTRO MAGNETIC RADIATION/ MICROWAVE EQUIPMENT/ PHASED ARRAYS/ REAL TIME OPERATION

Fig. 12 ESRO/ELDO standard profile



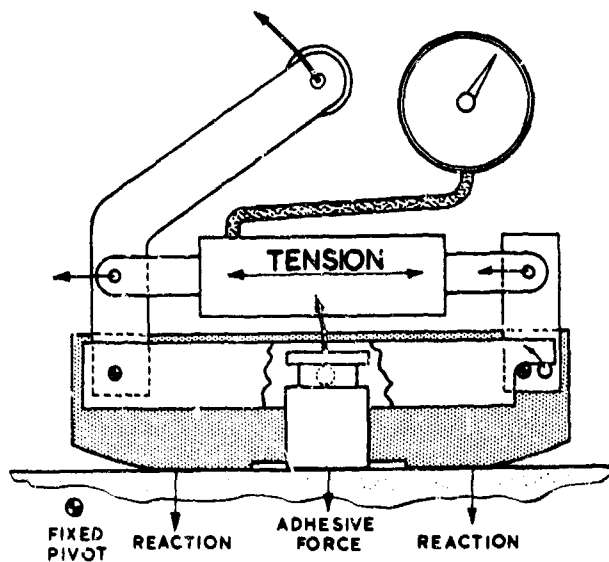
Techlink No. 536

Subject Code 6, 29, 42

ADHESION TEST FOR SPRAYED METALLIC COATINGS

A hand operated test machine has been developed for testing the adhesion of sprayed metallic coatings on to mild steel pipes.

A round test button of 1 in.² (640 mm²) is bonded to the sprayed metal surface by a cold setting epoxy adhesive. After curing, the sprayed coating is grooved round the circumference of the button until parent metal is exposed. The button is then attached to the test machine which employs a high mechanical advantage lever system to develop a pull on the button up to 2 tonf (20 kN) for a manual effort of about 35 lbf (156 N) at the handle. Interposed in one of the coupling links in the lever system is an automobile brake cylinder filled with hydraulic fluid and coupled to a pressure gauge. A maximum pressure pointer indicates the adhesion at failure of the bond between coating and base metal. Reactive forces hold the test machine in position until the coating has detached.



FURTHER INFORMATION on this device may be obtained from:
Materials Department, National Gas Turbine Establishment,
Pyestock, Farnborough, Hants. Tel. Farnborough 44411

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April 1970. ARR. Ministry of Technology Reports Centre. Techlink Unit,
Station Square House, St. Mary Cray, Orpington, Kent. BR5 3RE

Fig. 13 Example of a Techlink

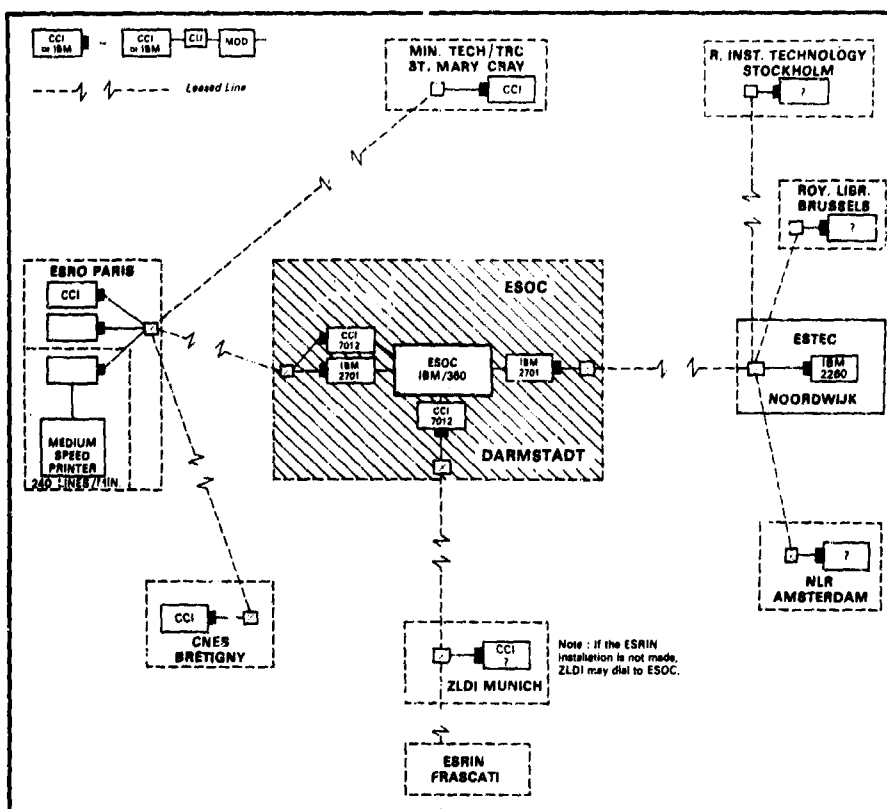


Fig. 14 Possible European network

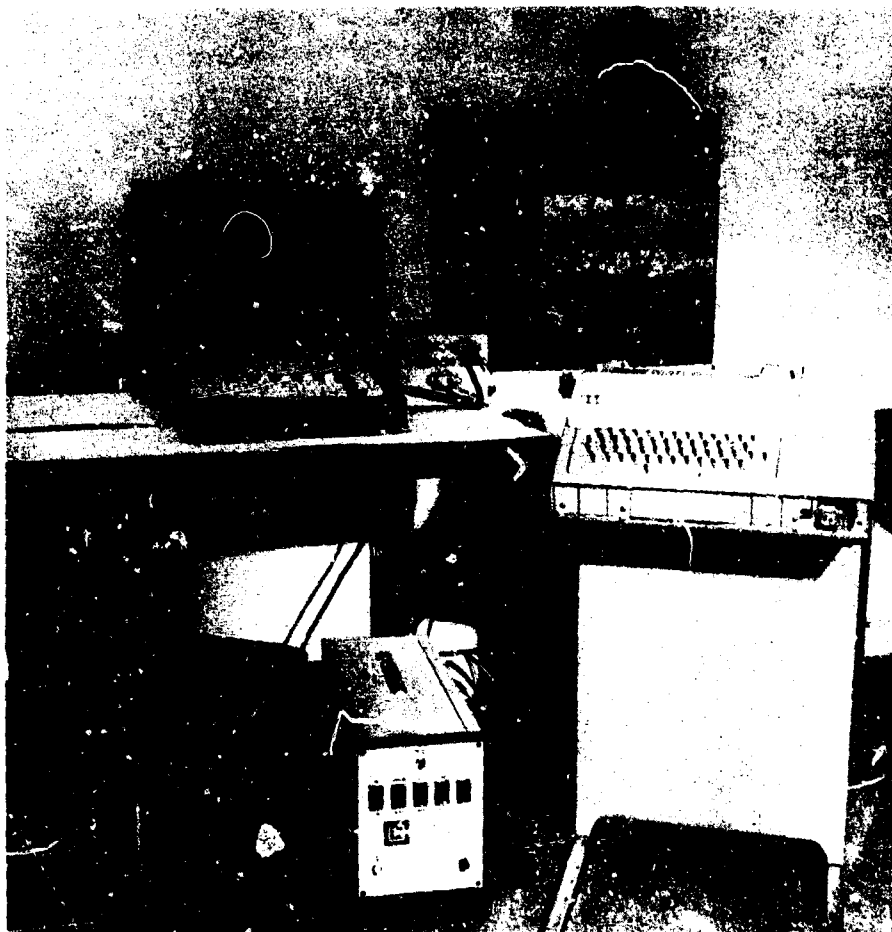


Fig. 15 RECON terminal equipment

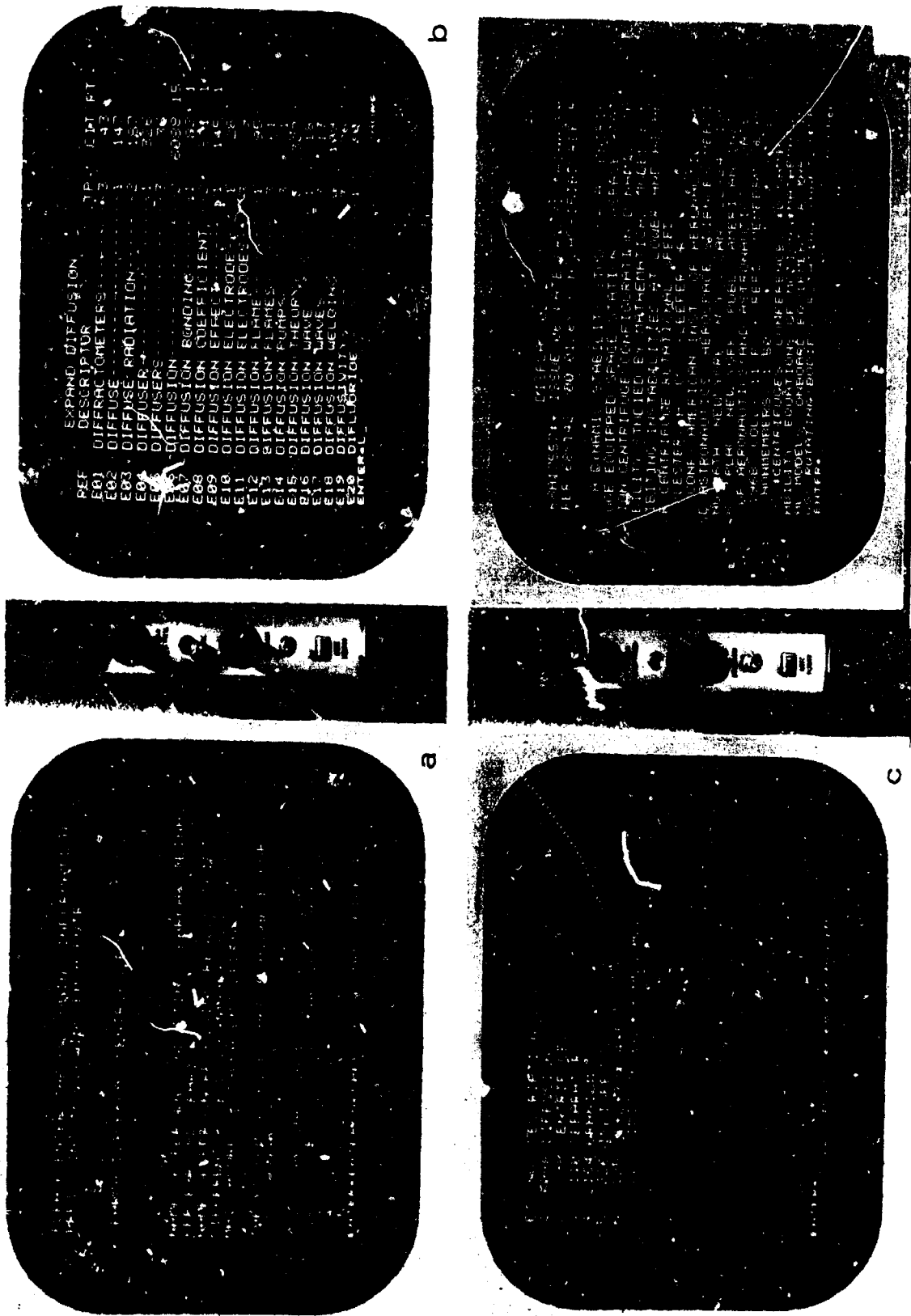


Fig. 16 RECON terminal display

CONCEPT, MISSION, AND OPERATION OF
SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS

by

G. S. Simpson, Jr and J. W. Murdock

Battelle Memorial Institute
Columbus Laboratories
Columbus, Ohio, USA

SUMMARY

The lecturers discuss Information Analysis Centers (IAC's) in three parts: concept, mission, and operation. Since there is an array of existing scientific and technical information services varying from the conventional library, through special libraries and document depots to IAC's, the first portion of the lecture considers what an IAC is, how it relates to other information services, and its fundamental concept. Color slides are employed as visual aids.

The second portion of the series treats the idea of the mission of an IAC. Accepting now that the participants understand the idea of an IAC, and how it relates to other specialized information services, the mission of an IAC is considered in the light of its users, or peer group, how unpublished information is obtained and used, and how feedback helps the IAC achieve its mission. Two non-government supported IAC are described along with one government center.

The third portion of the series considers operational aspects (administration and management) of an IAC. Based on close contact with over a dozen operating IAC's, the lecturers relate actual experiences pertaining to the recruitment and utilization of competent research scientists and engineers in information analysis work, advantages of working in an IAC environment, key problems in day-to-day operation, and the ever present problem of money.

CONCEPT, MISSION, AND OPERATION
OF
SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS

by

G. S. Simpson, Jr. and J. W. Murdock
Battelle Memorial Institute
Columbus Laboratories
Columbus, Ohio U.S.A.

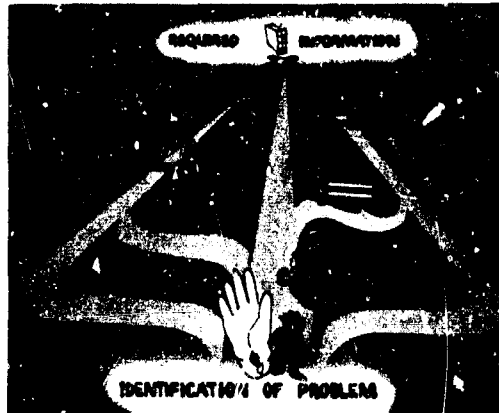
Introduction

Based on a combined forty years of experience, the authors present in this manuscript a description of the concept, mission, and operation of scientific and technical information analysis centers. Utilizing a series of 21 color slides and a 17-minute color talking motion picture, these topics are usually presented at briefings which are strictly informal and arranged on an ad hoc basis. So as to make available a preliminary copy of the briefing to be given at AGARD Lecture Series No. 44 in November, 1970, this paper will be based on the slides to be used, however instead of in color, they are reproduced herein in black and white. Our objective will be to provide sufficient information so that the listener, and/or the reader of this manuscript, will have a better understanding of the nature of a scientific and technical information analysis center, the most sophisticated information service presently existing.

Concept



Slide Nr 1 clearly shows the state of a person's feelings when he is confronted with the array of scientific and technical information centers and services currently existing.



The second slide shows the two major deterrents that prevent anyone from determining the sum total of all information centers and services as well as the total state of knowledge in any particular subject. It will be noticed that there are two main deterrents to the ultimate capability for knowledge transfer. These two deterrents are "need-to-know" which is a defense oriented requirement, and "proprietary information" which is a "dollar" oriented requirement. Obviously, nations have information in science and technology which they cannot release to the general public. This information we call defense oriented. The requirement not to release this information to the public whether it be purely in defense or a matter pertaining to international relations is widely accepted.

The second deterrent to maximum knowledge is caused by proprietary information. Whenever an industrial organization develops scientific or technical information which would provide that organization with a competitive advantage, a technological advance, or a completely new piece of hardware, the organization will not release this information until it either has obtained patent protection or a copyright.

Both defense oriented and proprietary information deterrents certainly prevent anyone from obtaining a total picture in any particular area. However, by the utilization of a scientific or technical information analysis center it is quite possible to intellectually compensate for that information not readily available. Having mentioned the two deterrents, we believe that our state of knowledge regarding the U. S. information centers and services approaches 90%, whereas our knowledge of information centers and services in the balance of the world we would estimate to be of the order of 20%.



Slide Nr 3 shows the array of scientific and technical information services and centers in the U. S. This slide, with its impressive number of special libraries and libraries, abstracting and indexing services, information analysis centers, and document depots, is illustrative of the problem facing anyone who wants to obtain selected information. Adding to these numbers the thousands

of technical reports being produced annually, the tens of thousands of scientific and technical articles being reported by the primary journals, and the literally hundreds of seminars and symposia with their proceedings, one can't help but develop a feeling of hopeless futility. Not only does one not know where to go to get the information or data he needs, but also he doesn't know which one of these facilities is most likely to serve him best. Finally, most technical people don't appreciate the differences among these several types of information services.

In order to arrive at an understanding of how an information analysis center differs from the other information services which are available, we are going to present a series of definitions. These definitions are simply for the purpose of explaining what we mean by the terms we are using.



**A COLLECTION OF BOOKS AND SIMILAR
MATERIAL ORGANIZED AND ADMINISTERED
FOR READING, REFERENCE, AND STUDY**



Slide Nr 4 contains our definition of a library, which is a collection of books and similar material organized and administered for reading, reference, and study. Libraries are not information analysis centers, as will become clear as our briefing unfolds.

The next type of information service which is widely known is the referral center as shown in Slide Nr 5.

REFERRAL CENTER

**AN ORGANIZATION FOR DIRECTING SEARCHES
FOR INFORMATION AND DATA TO SUITABLE
SOURCES SUCH AS LIBRARIES, DOCUMENT
DISSEMINATION CENTERS, INFORMATION
ANALYSIS CENTERS, DATA EXCHANGE CENTERS,
AND INDIVIDUALS**



Our definition is, a referral center is an organization for directing searches for information and data to suitable sources such as libraries, document dissemination centers, information analysis centers, data exchange centers, and individuals. In the United States a typical example of a referral center is the National Referral Center for Science and Technology located at the Library of Congress in Washington, D. C. This referral center is primarily concerned with directing individuals or organizations to specialized sources of scientific and technical information anywhere throughout the United States.

**AN ORGANIZATION WHICH SELECTS, ACQUIRES,
STORES, AND RETRIEVES SPECIFIC DOCUMENTS,
AND, IN ADDITION, ANNOUNCES, ABSTRACTS,
INDEXES, AND DISSEMINATES DOCUMENTS IN
RESPONSE TO REQUESTS**

Slide Nr 6 contains our definition of a document dissemination center. A document dissemination center is an organization which selects, acquires, stores, and retrieves specific documents and in addition announces abstracts and indexes, and disseminates documents in response to requests.



Slide Nr 7 indicates three major U. S. Government document depots, for example, the Defense Documentation Center which stores the technical reports produced by the United States Department of Defense Research and Development effort; the scientific and technical information facility of NASA, which stores the technical reports produced by NASA's scientific and technical R&D program. The third document dissemination depot represented on our slide is the Clearinghouse for Federal Scientific and Technical Information. The Clearinghouse primarily stores that information which is Unclassified and unlimited, and produced by any organization of the Federal Government. The information so stored is announced For Sale to the U. S. Public and to the World. Reports purchased can be either hard copy or in a micro-form.

In Slide Nr 8 we show our definition of an information analysis center. An information analysis center is an organization directed toward the collection of technical information and data in a specific area of effort, and its evaluation and filtering into a form of condensed data, summaries, or state-of-the-art reports. The balance of our presentation will be concerned with elaborating the concept, the mission, and the operation of an information analysis center.

INFORMATION ANALYSIS CENTER

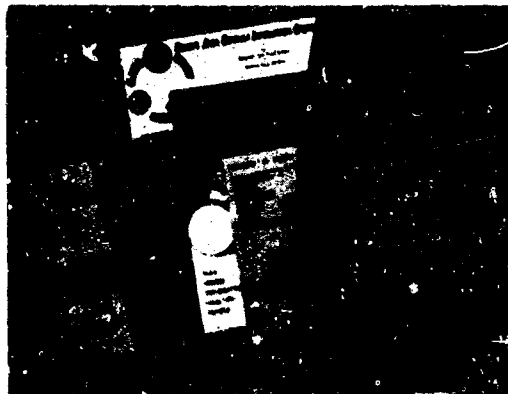
AN ORGANIZATION DIRECTED TOWARD THE COLLECTION OF TECHNICAL INFORMATION AND DATA IN A SPECIFIC AREA OF EFFORT AND ITS EVALUATION AND FILTERING INTO A FORM OF CONDENSED DATA, SUMMARIES OR STATE-OF-THE-ART REPORTS

Information analysis centers were created to overcome three major problems in scientific and technical information transfer namely:

- (1) the variety of ways in which information can be originated, whether through primary journals, secondary journals, letters, trip reports, technical reports, person-to-person, proceedings, or phone messages, each with its attendant different time lapses
- (2) scientists and engineers impatience with great masses of paper (most scientists and engineers would rather create new data or information from the laboratory than submit themselves to the drudgery of plowing through the plethora of stored information resources, many of which we've already mentioned)

and (3) management's critical need to know what the state of the art is now.

These three circumstances or problems still exist today and will exist indefinitely. And while it is clear that these problems can be overcome through the use of an information analysis center, the cost of such a center precludes their existing except in those areas where there is some combination of real need, great research and development activity, and progressive enlightened management.



Slide Nr 9 shows a number of pamphlets of information analysis centers sponsored by the U. S. Department of Defense. Since immediately after World War II information analysis centers have been growing in the United States at the rate of approximately seven per year. NASA has built numerous centers, the Atomic Energy Commission has created over 20, the Department of Defense has roughly 20, the Department of Health, Education, and Welfare has built in excess of 20, the Department of Agriculture has several, as have numerous other Government agencies and departments. The U. S. Private Sector has created numerous new information analysis centers, some to serve only a particular company, others to serve groups, for example: The Copper Development Association's Technical Data Center located at Battelle, Columbus. All of these centers, we must remember, have come into being while other information services continue to develop, for example the Library of Congress, the National Library of Medicine, the National Agricultural Library, the Defense Documentation Center, the

Clearinghouse for Federal Scientific and Technical Information. These libraries and document depots continue to grow and to automate, and at the same time, secondary services such as Chemical Abstracts Service, Bio-Abstracts Service, American Institute of Physics, the IEEE, the American Institute of Astronautics and Aeronautics, modernize and cooperate. While all these information services are developing, new primary journals are born, other primary journals expand, shrink, or die and certainly the number of society meetings, seminars, and all such continue to be held with consistent and certainly not decreasing regularity.

Raison d'etre

In view of the discussion thus far, a fair question, frequently raised, is Why Then An Information Analysis Center? Let's consider for a moment what it means to have all these information services that we've previously discussed such as a library, a special library, a documentation center, a referral center, thousands of journals and millions of articles, abstracting and indexing services, and our depots. Instead of answering the question direct, let's ask some new questions. Who is going to study all of the information being produced? Who is going to compress all of the information in any one subject area to ascertain what is going on, especially if he's using information from the published journals, most of which is already two years old? Who, with the fast turnover in personnel among organizations in Government, really knows what is going on in any particular subject anywhere in his own country as well as in the world? And in what subject areas do we really have to know what is going on? Is it to be expected that the average scientist and engineer can possibly know everything going on in his specialty?

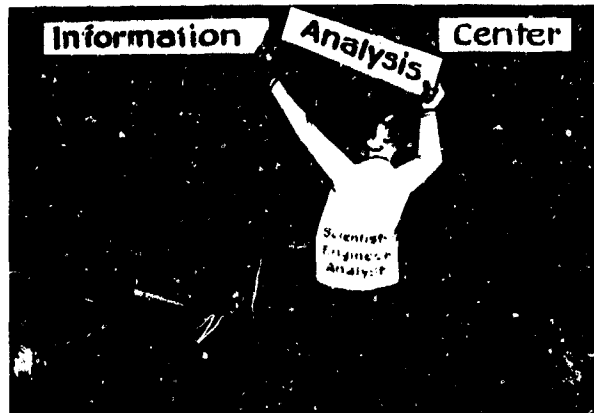
Most of us have to answer these questions in the negative sense; that is we really don't know what's going on throughout the world. But in many subject areas wherein there is great research and development activity and wherein there is a real need for a particular nation or a particular industry to make real progress, it is required that some one or more persons get on with the serious business of analyzing not only the published literature but any other input they can get. For this reason then, several nations and many industries have created information analysis centers. Utilizing not only the published literature but an entire array of other kinds of inputs such as trip reports, telephone calls, informal communications in the forms of letters, the foreign literature, as well as primary journals and face to face contact, compressions and analyses are produced by formally organized facilities whose main objectives are to determine what is going on.

This then is the raison d'etre, or the basic concept, behind an information analysis center. It is an organization of one or more scientists, engineers, and information specialists, committed at least part time to providing to a specialized audience the intellectual service of acquiring, evaluating, integrating, condensing, and analyzing available information or data pertaining to a specific mission. The center provides answers to technical questions and provides to its specialized audience authoritative and timely data arrays, analyses, monographs, or state-of-the-art reports. Slide Nr 10 shows a list of information analysis centers being developed within the National Standards Reference Data System.

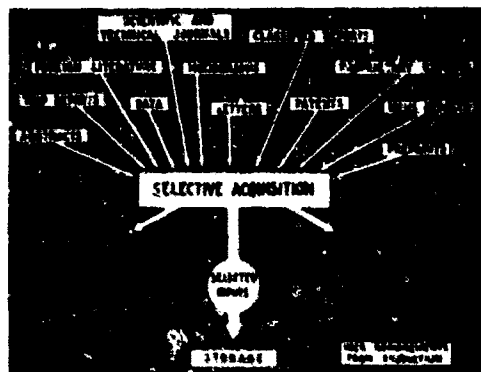
NATIONAL STANDARDS REFERENCE DATA SYSTEM

- NUCLEAR
- ATOMIC & MOLECULAR
- SOLID STATE
- THERMODYNAMICS & TRANSPORT
- CHEMICAL KINETICS
- COLLOID & SURFACE PROPERTIES
- MECHANICAL PROPERTIES

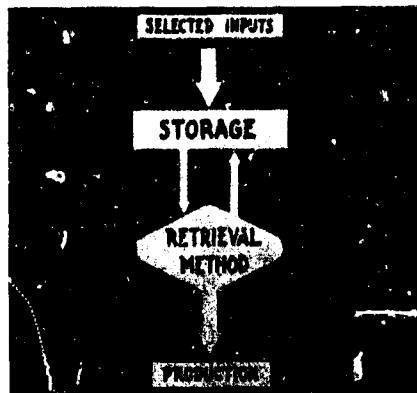
COFFEE BREAK

Mission

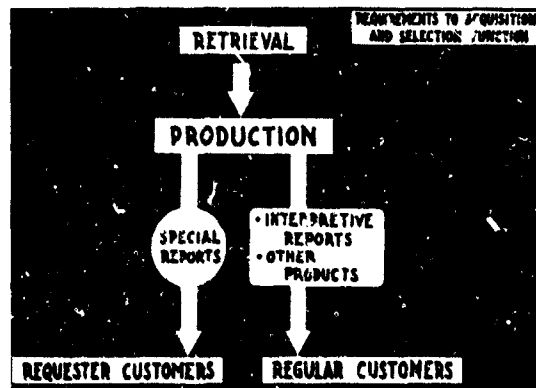
Slide Nr 11 is being used to introduce this portion of our briefing in which the mission of an information analysis center will be described. Notice in this slide that the word analysis is emphasized. Throughout the United States this word differentiates the information analysis center as an information service from all other information services such as libraries, document depots, referral centers, and abstracting and indexing services. The mission of an information analysis center is accomplished by the judicious application of effort to three main functions: namely, acquisition, storage and retrieval, and production. The objectives of the mission of the information analysis center are pursued through a series of scientific or engineering tasks involving one or more disciplines. Knowledgeable professional scientists or engineers are used to direct the acquisition function. The professional is used to obtain unpublished information as well as analyze published information. Obviously, this requires traveling, but traveling stimulates the analyst, it helps keep him in close contact with his professional peers and it provides him with added insight into the information needs of his technical associates. Also, utilizing a professional scientist or engineer to acquire unpublished information serves to announce the analysis center mission and to emphasize its technical orientation. The acquisition function is depicted in our twelfth slide, which as you can see is colored red for danger.



The mission of an information analysis center cannot be achieved without an aggressive and continuing acquisition program. Once the center has developed its sources of information, some of which may be as old as two years, but many others of which are as current as today, the center proceeds to its next function namely, storage and retrieval.



Slide Nr 13 is colored yellow for caution. In achieving the mission of an information analysis center it must be kept in mind that the main objective is to turn out analyses, not to spend all of your resources building a glamorous system or storing and retrieving information through the use of sophisticated devices. It is a very easy matter to become so preoccupied with the techniques and problems of the processing of information itself that one loses his recognition, of the objective, that the job at hand is to analyze, not just to store and retrieve. This viewpoint is further emphasized in our fourteenth slide which is colored green, for production, or for money. The point being - if your analyses are not well received, you are out of business.



Our twelfth, thirteenth, and fourteenth slides were as you will recall colored red for danger (acquisition), yellow for caution (storage and retrieval), and green for production or (money). These three colors are the same colors that are in most U. S. traffic lights.



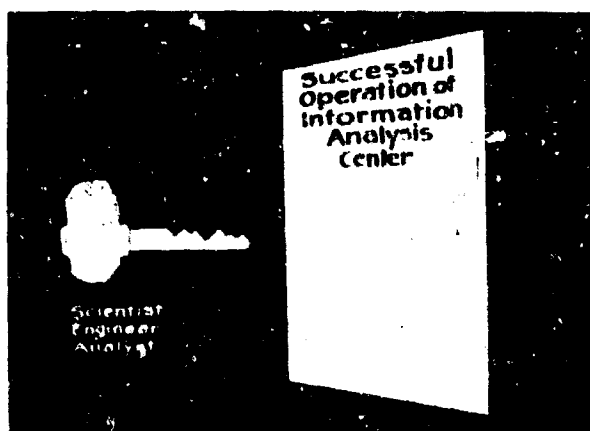
In a sense the overall operation of an information analysis center is represented by our fifteenth slide; let's consider this slide. We see a scientist/engineer dressed somewhat like Sherlock Holmes searching for the latest inputs in the area which he is analyzing. Having been given a specific assignment by his management, the scientist/engineer utilizes the information available in his storage and retrieval system as his starting point. For example, a typical assignment could easily be to determine the latest state-of-the-art in high-temperature metals development, and to recommend areas of research for continued development of improved alloys for jet engine turbine buckets. Clearly the latest work in this area is unpublished. Hence our analyst, finding out from the published literature who is doing the best research, where, and at what facility, will start to acquire directly from these people new unpublished information for use in his study. He will carefully integrate, analyze, synthesize, and compress not only the unpublished information he has obtained, but also that information which is pertinent and in his storage system. Once his analysis has reached a rough-draft stage, he frequently sends copies to other authorities who enjoy providing a critique of his effort. The result of the analysis is a state-of-the-art, a monograph, or a review. It is an intellectual contribution, frequently providing a new view of where we are, and where we should go. It always is a compression or repackaging of many, many items of information, some from the foreign literature, some domestic, some unpublished. And it always saves all the other technical people interested in the subject from having to read the heterogeneous literature pertinent to the topic.

To further discuss the mission aspect of an Information Analysis Center, three Battelle operated centers will be described; one is a U. S. Department of Defense sponsored center, one an industrial sponsored center, and the third, a Battelle sponsored center. Details on these centers are eliminated here in the interest of saving space.

Operation

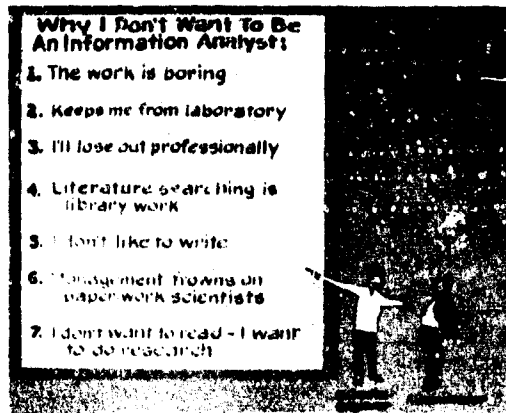
Like all other technical people with management responsibilities, we have developed a number of management and administrative principles applicable to information analysis centers. Some of our principles may not be unique to information analysis centers; indeed, some could well apply to other scientific and technical organizations. Whether they do or not you will have to decide, since the principles we will discuss have been based primarily on our experiences with information analysis centers operating in an applied research laboratory environment.

One fundamental principle in operating an information analysis center is that the director of the center must be a technical man. He should have had considerable research experience, and should have developed a favorable reputation among his peer group in his chosen field of technology. This is an absolute necessity if the information analysis center is to be considered other than simply a library. It is also necessary in order that the information analysis center technical staff receive a wholehearted reception as they go about their business of obtaining unpublished information. Our experiences indicate that a technical specialist is perfectly willing to discuss with another technical man things he is doing, including things which have not yet been published. But the interviewee is not likely to have too much patience with a person whom he identifies as being technically incompetent. Furthermore, and obviously, any product of the information analysis center is more likely to be well received by the technical group for which it is intended if that technical group knows of and respects the authors.



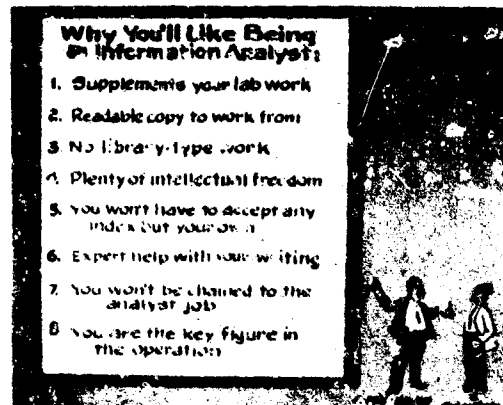
Slide 16 emphasizes the point which we have just been describing. Absolutely, the key element in the operation of an information analysis center is the utilization of competent scientific or technical analysts. It is almost impossible to over emphasize this element.

Generally speaking, scientists and engineers do not relish a steady diet of information analysis work. Of course there are some exceptions but in the main competent professionals are reluctant to participate in information analysis center work. The reasons a competent scientist or engineer gives are indicated in Slide 17.



The reasons, as indicated in our Slide, very clearly suggest the second important principle in the operation of an information analysis center, that is, obtain and maintain the interest of competent professionals.

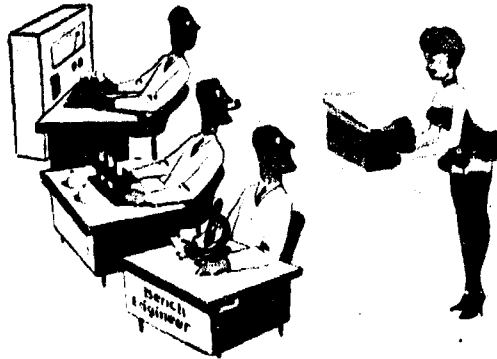
To obtain and keep the kinds of scientists and engineers you need in information analysis center work we have assembled a number of operational principles which we are indicating in Slide Nr 18, which follows.



We consider that these operating principles must be reasonably sound since we have been able to develop an information analysis center cadre of something of the order of 250 scientists and engineers, who are engaged, at least part time, in information analysis center work.

Having recruited the type of scientist or engineer you need for information analysis center work, a follow-on operating principle is not to forget to try to keep that person interested. Slide 19, which follows, emphasizes this also important operating principle.

Keeping Competent Persons Interested



Scientists and engineers who have participated in information analysis center work will state emphatically that the experience has done the following things for them:

- (a) the experience has broadened their view of science and technology
 - (b) the experience has improved their capability to communicate
 - (c) the experience provided them with the opportunity to master a particular technical topic at a faster rate than otherwise practical
 - (d) participating in information analysis center work has made them more aware of the value of foreign literature
 - (e) in accomplishing state of the art analyses they have frequently identified areas of needed research, which they in turn had the opportunity to accomplish
- and (f) because they have accomplished state-of-the-art analyses they are not obsolete or technologically inbred.

This last fact is so important for scientists and engineers who are in large organizations that we have pictured this advantage in Slide Nr 20.



We will conclude our briefing with a few comments about the cost of information analysis centers. They are expensive, varying from a small center with an annual cost of \$60,000 to a large center having an operating budget in excess of \$1,000,000. The size of a center's budget largely reflects its scope. That is, the broader the scope, the more technical people required, and of course, the more dollars required. We know of several private information analysis centers operated by U. S. industry which exceed \$1,000,000 per year annual budget, and we have two information analysis centers at our laboratory that have annual budgets in this range. However, most information analysis centers in the United States operated with an annual budget in range of from \$150,000 to \$250,000.

From these figures, it is clear that information analysis centers are justified only when there is considerable research and development activity, when there is a large body of information resulting, and when there is an urgency that technological progress be made. When these three circumstances no longer exist, an information analysis center is not justified costwise.



Slide 21 is presented to indicate a topic of widespread interest in the United States.

At present, the Federal Government of the United States supports approximately 118 information analysis centers. The cost of operating these centers tends to rise as more scientists and engineers direct their information needs to these centers. A debate is underway on the question - should government information analysis centers charge for their services? The question has not yet been resolved.