WADD TECHNICAL REPORT 60-867

CONSIDERATIONS AND RECOMMENDATIONS FOR DEVELOPING A MATERIALS INFORMATION PROCESSING CAPABILITY

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WRIGHT AIR DEVELOPMENT DIVISION

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Materials Central
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WRIGHT AIR DEVELOPMENT DIVISION
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FOREWORD

This report was prepared by the Belfour Engineering Company under Contract No. AF 33(616)-7064. This contract was initiated under Project No. 7381, "Materials Application", Task No. 73812, "Data Collection and Correlation". The work was administered under the direction of the Applications Laboratory, Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Mr. D.A. Shinn acting as project engineer.

This report summarizes work done from February 1960 to November 1960.

ABSTRACT

A survey is summarized in conjunction with recommendations for the development of a Materials Information Processing Capability at the WADD Materials Central. The discussion covers some basic concepts of technical information, user requirements, and existing information "centers". A consistency in pattern of information processing techniques is examined and discussed. Recommendations are given for the development of a Materials Information Processing Capability.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

D.A. SHINN
Chief, Materials Information Branch
Application Laboratory
Materials Central

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I. INTRODUCTION

In developing recommendations pertaining to the establishment of a general Materials Information Processing Capability, the problem was divided into two major and relatively independent categories: the first (Phase I) was to study, identify and understand the needs which the capability would fill; the second (Phase II) was to study existing programs of this type, their suitability, effectiveness and general experiences in the relatively new field of automatic information processing. We were also interested in the possibility of incorporating existing programs into the contemplated capability.

Detailed study of equipment applications has been postponed until such time as there is reasonable agreement on the needs, goals and scope of the problem. With few exceptions[1]* there is the general feeling that existing equipment will be adequate, once we know exactly what we want to accomplish.

The term "information processing" used in describing this general type of problem differs from "data processing" in that a relatively large amount of descriptive information is necessary to adequately define a numerical value, attribute or property in the former case, while a simple column heading usually can describe a series of numbers, attributes or properties in the latter. The results of fatigue tests, creep tests, environmental and other complex test procedures, require detailed descriptions to be meaningful. Most accounting tabulations and some of the well established and well defined physical properties test results may be understood through a simple column heading. Even the latter are becoming more complex due to the increased requirement for defining environmental parameters and refinements of test techniques necessitated by the critical demands made of materials.

II. PHASE I

A. SUMMARY

USER EVALUATION: During Phase I of this project we were concerned principally with determining the criteria for the establishment of a materials information processing capability. The problem was discussed with a representative group of contractors, the potential users of this capability. Interviews were conducted with personnel representing research institutes, universities, airframe manufacturers, materials producers and various government agencies. The anticipated desire for more and better information was confirmed by all these groups; the form and type of information described by the potential users varies considerably. Given a materials information processing capability, different users would prefer output in forms such as bibliographies, abstracts, data sheets, and handbooks. The most extreme aspiration is for a computing system which searches its memory and submits the optimum material based on an input of various design parameters.

Manuscript released by the author November 1960 for publication.

* Numbers in brackets refer to the bibliography.

Many of the groups interviewed indicated a relatively strong desire to control the availability of materials information to certain sub-groups within their particular organizations. In some cases airframe manufacturers insist that only those responsible for R & D and the preparation of company manuals receive basic materials information. One large materials manufacturer directs his central technical librarian to intercept all technical literature and simply send out availability announcements on a general distribution basis. This procedure is not uncommon in the larger organizations. Smaller companies are willing to allow and even encourage most of their personnel to receive basic data indiscriminately from any source.

Procedures by which technical information gets to an individual user vary and, in general, seem to be of secondary interest to the present study. Most of the established procedures by which information is made available to engineers are based on the experiences gained with more familiar information forms. Typical of these are published technical reports, trade journals, texts, etc. The way in which information is then used to solve a problem is, of course, dependent on the form in which it is made available and the ingenuity and enterprise of the engineer. We will demonstrate later in this report that a concept of automatic processing can provide an information form that may result in modifying some of the ways in which information is used to solve problems.

At this point in the development it is important that we understand that the potential user is not in the best position to evaluate the types of information systems being developed. A study conducted in 1958 [2] demonstrates the inadequacies of "use studies"—particularly when the user is asked to evaluate a product with which he has had no experience.

The user's <u>needs</u> are important, however, and as such will take precedence over his recommendations on how an information capability should satisfy those needs.

<u>TYPES OF INFORMATION</u>: For the purpose of developing the contemplated materials information processing system it is suggested that information be defined as "that which forms the basis for intelligent action". [3]

The contemplated system is being developed, primarily, to serve the needs of those concerned with the <u>application</u> of materials information. The information content of this system's memory must be in such a form that its output may provide the basis for intelligent action; in other words, information that can be applied directly to the development of structural integrity and manufacturing processes associated with end-items. We will define this as <u>primary information</u>. Further application of primary information for research purposes is possible and has been demonstrated [4]. The availability of a large number of empirical data points, in combination with many identified and graduated parameters, suggests such research as: fitting theory to observed data, the performance of reliability and other statistical studies, determining the effects of processes on material properties, etc.

Secondary information, such as references and bibliographies, is an intermediate step in that it only provides the address to primary information. As such it is in the realm of library science. Considerable work is being done to improve the availability of this type of information.

PROCESSING OF PRIMARY INFORMATION: It is an established fact that large quantities of pertinent data and descriptive information can be made available at high rates of speed and from a considerably wider viewpoint than has been available in the past. High speed data processing equipment has made this possible [5] [6] [7]. The developments themselves are simply logical continuations of the familiar decimal filing and cross referencing systems. The important difference is that when the hand operated systems become clumsy and unmanageable, due to extensive cross referencing and large number sizes—the automatic data processing equipment takes over and does most of the routine, repetitive and tedious work.

There is almost no limitation on the number and types of descriptive or cross referencing terms which can be incorporated with the aid of machine processing systems. The information and data contained in any report can become its own cross reference in an automated system. It is that information (primary) which is retrieved as a result of any search. The suitability of primary information as a main output form is dependent on the manner in which this type of information will satisfy the needs of people engaged in technical developments involving materials and processes.

USER CATEGORIES: Considerable argument has been encountered [8] concerning the desirability of separating the audience (users) into at least two categories and designing different types of information systems to satisfy the two most obvious categories of users: scientists and engineers. This subject stimulated a discussion at the National Science Foundation where differing viewpoints were defended. One viewpoint held that it is dangerous to divide and generalize about the potential users of the system. The other held that the type of information required by scientists and engineers is so different that one system could not efficiently satisfy both groups.

In studying this aspect of the problem we attempted to determine what, if any, differences exist in the literature requirements and literature searching habits of both groups. Both are interested in the same end-item: information. The only difference appears to be that the scientist may put more emphasis on the bibliographic form than the engineer. However, the scientist's and engineer's fields of endeavor are becoming more difficult to separate. Considerable overlapping exists.

The rapid pace of aerospace technological development demands that the engineer utilize the most current scientific information available. He is often forced to use information before its reliability has been established. Basic studies in the field of materials performance in space environment are being conducted with almost no lead-time on the practical application of these studies. The engineer is breathing down the scientist's neck. In many cases technological gaps force him to assume a classical scientific role in order to fill an information void. It is, therefore, quite realistic to expect only minor differences in the information needs and requirements of both groups.

B. REQUIREMENTS FOR THE DEVELOPMENT OF A MATERIALS INFORMATION PROCESSING CAPABILITY

THE CASE FOR PRIMARY INFORMATION STORAGE AND RETRIEVAL: Many of the topics discussed above leave what appear to be more perplexing and unanswerable questions. In reviewing the problem, there are only two areas where there is any general agreement. This agreement yields a paradoxical situation. In this paradox, however, is a strong indication of the requirements for a materials information processing capability. We all want more reliable information pertaining to our problems, and want it faster. Concurrently, we agree that there is not enough time available to read and evaluate all the information which we now receive.

The first statement is often loosely interpreted to indicate a lack of good technical information. The case is simply that more good technical information exists than anyone can get his hands on without what seems to him an undue effort.

We shouldn't forget that good literature searching procedures often result in the discovery of considerable pertinent and useful information. The information is available. The only question is, can we improve on the traditional methods for getting information to those who need it?

The answer is indicated in the statement of the second area of general agreement; that is, we don't have time to read and evaluate all the information which we receive at present. The solution to the engineer's technical information problem is not to provide him with more publications or addresses to publications at a faster rate, or on an automated basis. The solution must provide the engineer with a ready source of primary, useful information pertaining to his immediate problem. This approach may not significantly broaden the engineer's general knowledge —we must leave this to the libraries and his personal initiative.

Some libraries are beginning to take advantage of digital computers and digital computing techniques to speed up the retrieval of references [9]. Automatic systems of this type offer significant gains in speed over the usual cross referenced, index card systems. More important, they can provide more depth of indexing and therefore can identify more subject matter. However, the result is still the same as it was in the past: a report or publication of some sort—usually a group of these—which must be read and evaluated in the same old-fashioned way. This is not meant to indicate that we feel reading reports is passé; nothing could be further from the truth. However, if insufficient time is available to study a subject thoroughly—this seems to be indicated in most cases—the contents of publications pertaining to that subject must be made available in an abbreviated form which can be readily evaluated.

This form is, in reality, nothing new to the engineer. Graphical and tabular presentations are commonplace and display at a glance the relationships and interactions between phenomena that concern him. By storing descriptive information and the associated empirical data, the system's output can provide a cross section through representative empirical knowledge pertaining to any material subject.

In some respects systems that store primary information can actually improve on usefulness of data by exhibiting them with all other comparable information. The answer to a question is rarely a single data point taken from one source. Experience with relatively small systems [6] [7] indicates that in answering a typical question, information is automatically drawn from a number of sources and involves many data points. Although the original detail may suffer due to the necessity for translating syntax into common machine language, the system compensated for this by forcing an investigator to consider everything in the system's memory that pertains to his question.

SPEED: One of the requirements of the contemplated materials information processing capability is that it provide information in a useful form which is not available elsewhere (libraries). We assume that this should be accomplished quickly. The speed with which any search and retrieval is accomplished must be a function of realistic and practical needs, rather than a function of awe-inspiring capabilities of high speed computers. A time lapse of a few weeks between question and answer is no significant improvement over present conditions. A time lapse of a few seconds between question and answer seems to indicate over-design [10]. In general, retrieval times in the order of minutes for simple questions (2-3 parameters) ranging to a few hours for more complex searches (involving the definition of more parameters) would be compatible with the requirements of industry. Higher retrieval speeds or shorter retrieval time might be necessitated by the rate at which questions are asked. This is a problem of internal operation which can be solved by numerous data processing techniques when and if it arises in the future.

III. PHASE II

A. ESTABLISHED PATTERNS IN INFORMATION PROCESSING

Approximately 500 current data processing and information processing programs were examined during Phase II. We hoped to find patterns in approaches to information processing developments that would begin to indicate a trend. We use the word "begin" advisedly, since all the past survey results which we have studied report a high degree of confusion and chaos existing in the field of information processing[11].

In reality, a considerable amount of agreement exists in the basic approach to information processing. The extent of agreement in approach, equipment type and use is truly remarkable when we consider that almost all of the existing projects are the result of independent developments. The best examples of information processing projects of this type are given in the National Science Foundation's publication entitled "Nonconventional Technical Information Systems in Current Use" [5].

The consistency in approach to processing technical information can be summarized as follows:

1. Manual extraction (from source document)
2. Manual or semi-automatic encoding
3. Random access storage
4. Search by sorting or matching
5. Output by tabulation and plotting

Almost all the established systems which are actually in operation use manual extraction and transformation of information (from original data sources). This information is then encoded where necessary into a unique alpha-numeric or binary position code and entered into formats which have varying degrees of flexibility. The information is then stored in one of many types of random access storage systems. Information is retrieved by sorting for attributes or matching with a predetermined array which constitutes a question.

Virtually every type of data processing machine and computing system has been used to accomplish the storage and retrieval of information. No matter what type of equipment is used, the application is almost always one of high-speed sorting or matching. Most operational systems incorporate manual techniques to get a search started in the right or most fruitful area in a random access filing system, rather than allow machines to search through and reject large blocks of non-applicable data.

The procedures described above are used in both systems that store references and systems that store data or information. In almost every case the machines used in these systems fall into the category of peripheral equipment [12]. Large capacity, random access computers are available when and if the systems grow big enough to justify their use.

The "golden rule" governing the success or failure of a development as comprehensive as a Materials Information Processing System is to "avoid the 'universal solution' concept" [13] and optimize each problem area individually, rather than compromise for the sake of overall uniformity and degrade the value of the entire system.

B. USE OF EXISTING CAPABILITIES

The existence of a materials information processing capability nucleus was demonstrated, in a matrix form developed during this contract. Figure 1 is a condensed and idealized version of this matrix. This simplified form is used for the sake of clarity. The potential of this approach to organize and identify the overall capability is clearly demonstrated. All current materials information processing efforts can be displayed on this type of chart. The relationship between programs concerned with properties, as a subdivision of the material types, and those concerned with materials, as a subdivision of property types, is indicated.

One deficiency of this type of matrix is that its two-dimensional form does not indicate the level of information available at the different centers. Most of the centers indicated on the matrix store and retrieve secondary information (references). A few actually store and retrieve primary information (numerical data and description of significant conditions). A three-dimensional construction of this matrix would not be difficult. The resulting array would indicate at a glance almost all the important aspects of the organization and activity of a materials information processing capability.

The organization matrix discussed above was developed from a highly cross-referenced file describing approximately 500 current data and information processing projects.

C. MANAGEMENT

In order to utilize effectively all the current information centers in a true overall capability, it is obvious that a central management must be established. Any display of an existing capability is artificial, since the interrelationship of most current programs within the overall organization is accidental. Existing projects can disappear or change emphasis at any time. A central management is necessary in order to provide organization and direction to the entire effort. Management can be effective only if it controls the finances available to the current programs and the development of new ones which are indicated by voids in required information areas. Someone is paying for all the unorganized work that is now being conducted.

There is, at present, a complete lack of overall purpose and goals, coupled with considerable duplication of effort. The effect on potential users is that they are, in general, unaware of the existence of any form of general materials information processing capability. The total cost for providing this capability with central management and centrally controlled financing will probably be less than the present rate of expenditure.

D. USER INTEREST

All the indications are that the users' interest in an established materials information processing capability will be slow in developing. The real value of the contemplated system is in the service it provides to those who need available materials information. This applies as well to the use of current information sources, such as libraries, as to the new concepts which we propose for the future. The only hope we have that available information will be used intelligently depends on personal initiative and the integrity of the individuals involved in research and development programs.

Personnel who act as contract project engineers must insist that current knowledge—which has already been purchased—be applied intelligently to new programs. Contractors must assume the responsibility for current awareness in all their problem areas. The contemplated information processing capability is intended to ease that burden as much as possible.

Our experience [6] [7] has indicated that specialized information centers can provide pertinent data on their own initiative, if they are made aware of existing problem areas. Once the initial contact or relationship is established, more specific information can be made available.

The initial contact, whether it originates from a contractor's plant or from the information center, depends on the initiative of individuals. For the purposes of this development, Air Force personnel must accept the responsibility of insisting that current knowledge is utilized in all applicable areas.

IV. CONCLUSIONS AND RECOMMENDATIONS

Review of the work accomplished by this survey leads us to the following conclusions and recommendations:

A. CONCLUSIONS

1. The effort involved in finding pertinent materials information tends to discourage the efficient use of available knowledge.

2. Demands made of materials require that, in most critical applications, materials properties be defined and utilized as statistical quantities. This imposes the condition that designers have available more information than was necessary in the past; at least enough data to accurately indicate the variability of materials properties.

3. Many programs have been initiated to apply high speed machine processing techniques to aid in literature searches.

4. A few programs have been initiated to store and retrieve actual information and empirical data content of technical literature in the memory of high speed data processing systems.

5. The nucleus of an existing materials information processing capability can be demonstrated.

6. Sound argument has been presented that current "user interest" is a poor measure of the ultimate utility of technical information centers.

7. Most existing "information centers" are independent of any central control, management, purpose or goal.

8. In most instances, different "information centers" search through identical literature in order to find information pertinent to each center.

B. RECOMMENDATIONS

1. Separate and identify data processing projects concerned with primary (numerical data and descriptive information) and secondary (references and abstracts) information. Encourage development work in both areas.

2. Develop and maintain, on a current basis, a matrix identifying and locating "information centers", showing the subject matter and level of information available at each. This is the materials information processing capability.

3. Provide management, coordination, permanence and direction to the capability.

4. Encourage contract administrators to insist on the intelligent utilization of the materials information processing capability.

5. Develop a central literature searching activity which searches a definable portion of current and historical technical literature, and routes pertinent information to each center for processing. This activity will relieve the individual

centers of this costly and time consuming duplication of effort. The review of trade journals and similar publications which are concerned with a relatively specific subject area should still be conducted at the appropriate centers where that information will be stored.

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