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Computer Science & Technology: Investigation of Technology-Based Improvement of the Eric System

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Institute for Computer Sciences and Technology
National Bureau of Standards
U.S. Department of Commerce
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INVESTIGATION OF TECHNOLOGY-BASED IMPROVEMENT OF THE ERIC SYSTEM

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Abstract

Results of a one-year, NIE-sponsored study to identify potential technology-based improvements in the operation, access, and utilization of the Educational Resources Information Center (ERIC) are described. Both current problem areas and future possibilities are considered with regard to the dichotomy: system components and the total system. Emphasis is on characterizing the component functions of data input and data output as well as the total system operation in terms of applicable criteria (data type, volume, purpose, performance). Technological alternatives are then discussed with reference to those criteria. The report concludes with a structured summary of observations, recommendations, and possible follow-up studies.

Key words: Educational Resources Information Center (ERIC); information systems; micrographics; microfiche; computer technology; communications technology; data entry; optical character recognition; computer networks; distributed processing; intelligent terminals; mass storage technology.

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1. INTRODUCTION

With apparently ever increasing advancements being made in the area of technology involving information storage, computer processing and communication, it is a tremendous challenge for administrators of information systems to stay abreast of the state-of-the-art and to initiate commensurate system modifications which will benefit the users. This is particularly true in the case of an operational information system of national (and international) importance for which the substantial population of current and potential users exhibits an enormous diversity of needs, expectations and preferences: some are conditioned to the present system and like things as they are, others don't; some want minor changes, others insist on major ones; some are comfortable with technology-based system improvements, others prefer to minimize human dependence on technology; some are in fact users, while many who could be are not--for whatever reasons. Needless to say, it is extremely difficult to redesign the system to encompass and satisfy all of the above.

1.1 Study Groundwork

The Educational Resources Information Center (ERIC) of the National Institute of Education (NIE) was designed and developed in the 1960's. A good early description of that system is found in an article by Marron published in 1968 [ERI-1].* The components and types of products of ERIC, as they existed at that time remain remarkably similar to their present-day versions, although a long list of commendable improvements have been made over the years [ERI-2]. Marron's paper also makes several important points with bearing on this study. Firstly, ERIC was envisioned to be an information system "available to all segments of education," including teachers, administrators, planners, supervisors, counselors and students. However, it was realized that ERIC would definitely need help to achieve such an ambitious goal, through the development of a supportive network of resource organizations such as regional educational laboratories, various state agencies and numerous local information centers. This, then, led to advocacy of the wholesale-retail concept for ERIC which still appears to exist today. That is to say, ERIC was to be the "wholesaler" of information products and services while various other organizations would assume the retailing of those products and services and, hence, the direct

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*Note: Due to the multi-facet nature of this project, the BIBLIOGRAPHY is organized into categories listed in alphabetical sequence according to three-letter mnemonic labels representative of particular subjects. With each such category, e.g., ERI (standing for ERIC Description), a selected set of publications is listed in numeric order.

interaction with the massive user population.

Secondly, ERIC was viewed as a kind of hybrid system from the standpoint of being partly centralized and partly decentralized. The latter applied (and still applies) to subject specialists working in the then 19 (presently 16) ERIC clearinghouses located throughout the U.S. to provide input to the system; decentralization also, of course, applies with regard to the above-mentioned type of retail delivery of information to users. On the other hand, ERIC was portrayed as centralized in terms of document processing, computer activities and management functions pertaining either to Central ERIC (i.e., the NIE-based ERIC management) or the ERIC contractors (e.g., for producing microfiche of ERIC documents). Both advantages and disadvantages of such a hybrid approach to the structure and control of a nationwide information system/network were indicated by Marron.

For purposes of this study, the above highlighted points about the original (and still largely retained) design philosophy of ERIC, are significant. They will be seen to have considerable influence, both in positive and negative respects, on questions of potential application to ERIC of state-of-the-art technology. Finally, in setting the stage for the objectives and scope of this research work, it is interesting to note Marron's description of a goal for ERIC [ERI-1]: development of an on-line, remotely accessed search system for the ERIC files, with the aim of allowing "any interested institution to interact with the ERIC database, from any place in the country, or the world, using a commercially available communications system." At face value, this quote points to the powerful computer/communications networks available today. To what extent ERIC has achieved the above 1968 stated plan will be observed through the functional description of the current ERIC system to be presented in Section 2.3. To what extent ERIC could or should utilize technology to improve its information products and services underlies the objectives of this work. Before describing those objectives, more should be said about the ERIC-related literature.

1.2 Pertinent Literature

A variety of publications presenting the characteristics and uses of ERIC is available and was used for this study. Such descriptive material is identified in the "ERIC Description" or ERI category of the adjoining bibliography. However, ERIC has also been the subject of much public discussion and evaluation over the last decade. Ample examples of both praise and criticism can be found in the open literature.

Among the most substantial (although already dated) ERIC evaluation studies is the one carried out by Frye [EVA-1]. It should be noted that its emphasis was on evaluating ERIC products and services, by means of survey techniques for measuring use and user reaction. While results of such a study may carry implications for improvement of the system (as will be evidenced later), they must not be interpreted as representing a direct system evaluation as such.

Many other studies, e.g., Steiger's work which focussed on retrieving product information from ERIC [EVA-2], could be referenced here and characterized with regard to differing evaluative emphases. However, a more compact and efficient way to accomplish that purpose is to identify a recent NIE-sponsored study by Havelock [EVA-3]. His paper reviews over thirty empirical investigations into one or more aspects of the ERIC system, carried out during the period 1969 to 1977. Descriptions of applicable methodologies and salient findings are included.

Among the most interesting and pertinent results of Havelock's work, speaking in behalf of the ERIC evaluation studies collectively, are the following:

1. The bulk of ERIC searching is still done by hand. However, particularly in recent years, considerable interest in on-line searching has been shown. In fact, if there appears to be an area of rapidly expanding and strongly advantageous use of ERIC, it is on-line searching. Users of on-line facilities report very high levels of satisfaction, especially with regard to speed and flexibility.

2. Input processing practices among ERIC cleringhouses vary considerably with little agreement or coordination of effort. Also the studies analyzed by Havelock exhibited a lack of information on "ERIC as a whole," e.g., with respect to interconnections among its component parts.

3. Almost three-fourths of the standing-order customers of microfiche are colleges and universities, suggesting limited access to that medium by the vast majority of other educators. ERIC is actually used by a small proportion of those for whom it has potential relevance and benefit.

4. The most salient and consistent finding across the studies reviewed is the need for services that are highly localized and immediately and easily accessible. Apparently, the vast majority of potential ERIC users do not use it because they

perceive a lack of such local accessibility. Regrettably, because most ERIC studies consider only persons who are ERIC users already conditiond to ERIC accessibility as it exists, the "potential" user concerns are neglected.

5. No credible or reasonable approach has been found for subdividing or partitioning the ERIC file to render access more effective and efficient for special categories of users.

A draft copy of Havelock's report [EVA-3] was made available to this project several months after the latter started in 1978. The above-stated (often literally quoted) results will be shown to provide confirmation or reinforcement for various technology-based improvements of ERIC to be suggested in our work.

1.3 Objective and Scope

Consistent with the originally stated project scope, the primary purpose of this study of the ERIC system was to identify potential improvements in the operation, access and utilization of the system through the application of state-of-the-art technology both to system components and to the system as a whole. The improvements were to be presented in terms of possible alternatives along with indications of associated benefits to be derived. In so doing, this report was to suggest or point to specific avenues of further, more detailed study, design and, perhaps, implementation involving ERIC; it was not itself to result in actual design specifications for any particular technology-based alternative described.

Besides considering the above-mentioned dichotomy between component- and total system-orientation (to be clarified further in the next section), this study was also to address the question of ERIC improvement from both of the following standpoints:

1. Given identified <u>problem areas</u> in the ERIC system, how can technology serve to alleviate if not eliminate them?

2. Given known <u>advancements in technology</u>, how can they be brought to bear on the ERIC system?

With regard to the former, the NIE specified several problem areas of particular concern. These could generally be characterized as pertaining to interest in improving or determining alternative technological means and modes for: inputting or representing documents and surrogate data, followed by storage and updating of the resulting data base, and leading to outputting or presentation of those documents/data to the users. Elaboration on these study interests, supplemented and then prioritized in agreement with the NIE, is provided in Section 2.

As far as the second above-stated study standpoint is concerned, we were given the freedom to consider any other prospective application of technology, ranging from the area of micrographics to mass information storage devices to computer/communications networks and distributed processing. The work was, therefore, to be partly pragmatic in nature with respect to currently feasible problem solutions and improvements and partly futuristic or "blue sky" with regard to desirable but, perhaps, not yet economically or otherwise attainable use of technology. That attractive license to consider virtually any reasonable application of state-of-the-art technology for the improvement of ERIC was, of course, necessarily constrained by the limited one-year duration and the relatively small level of effort allocated to the project. Furthermore, as is to be expected, NIE-indicated priorities on study topics were followed. Consequently some topics received considerably more attention than others, and still others had to be neglected or altogether omitted.

1.4 Supportive Resources

In addition to the pertinent information to be found in the literature, as reflected by the adjoining bibliography, this project was significantly dependent on the availability and cooperation of a number of resource personnel who were actually visited and consulted to varying extents. Members of the following NIE/ERIC-associated staffs were involved:

1. Central ERIC staff (Washington, D. C.)

2. The staffs of almost half of the ERIC clearinghouses (located in the Washington, D.C. area, Ohio and Illinois)

3. ERIC Facility staff (Bethesda, MD)

4. ERIC Document Reproduction Service-EDRS (Arlington, VA)

5. Research and Information Services for Education-RISE (King of Prussia, PA)

Other ERIC-related personnel were contacted less formally at conferences or through telephone calls.

Supportive resources were also made available within the National Bureau of Standards. The principal investigator had access to a number of experts in the areas of micrographics, computer/communication networks and distributed processing, and other technological specialities. Noteworthy contributions are acknowledged where appropriate in the text of this report and/or through listings in the bibliography.

1.5 Guide to this Report

To generate a readable and useful product for the NIE, this report is purposely organized and indexed to facilitate access to its contents. Firstly, the approach to conducting the study is described in Section 2. It includes the methodological considerations, foci of attention and study priorities which were used to guide the investigation. A functional description of the current ERIC system is also presented. The reader who is already familiar with ERIC and less interested in methodology and priorities than in study results may wish to skip Section 2 and go directly to one of the other sections.

The reader can access this report in either of the following ways:

1. Guided by the subtopics listed in the <u>Table of Contents</u> under each of the three major result chapters,

   Section 3: Component-Oriented Considerations

   Section 4: Total System-Oriented Considerations

   Section 5: Conclusions and Recommendations

   identify and locate the corresponding report segments.

2. Guided by the <u>Subject Index</u> which is attached, determine whether and where something is said about a topic of interest.

The first, above stated approach to accessing study results confirms the objective (see Section 1.3) of considering technology application prospects both for ERIC system components (Section 3) as well as for the ERIC system on the whole (Section 4). In each case, pertinent characteristics and criteria are developed and use of tabulations of available alternatives is made, tied into discussions of the pros and cons in the text.

Sections 3 and 4 are intended to present the spectrum of assessments made and prospects identified in this study, both with regard to current as well as potential future use of technology in ERIC. Many specific suggestions for ERIC are interspersed in those sections. However, a concentrated summary of conclusions and recommendations affecting ERIC is not made until Section 5. The reasons for this separation include our perceived need and preference to place recommendations on technology-based improvements of ERIC in their proper context. That is to say, for a large, complex system such as ERIC (and its associated, supportive information centers), technological innovations or improvements can be suggested; however, the likelihood of their success or possible acceptance is necessarily questionable until or unless other, perhaps "nontechnical" but highly influential factors are taken into account. These factors may be sociological, psychological and economic in nature. Because we were able to elicit a number of such influences during the course of this work, we deemed it preferable to add appropriate qualifiers and conditions to our recommendations. The interested reader, therefore, has the additional alternative of going directly to Section 5 for such context-based results.

2. STUDY APPROACH

To foster better understanding of an investigation into how a particular system might be improved using technology, it is incumbent on the investigators to describe the system studied, the methodological guidelines established, the definitions employed, the assumptions made and any other factors which serve to clarify and delimit the basis and applicability of the results obtained. As was stated earlier, this section may be omitted by the reader who already knows the ERIC system well and is primarily interested in a cursory look at the results found in one or more of Sections 3 through 5.

2.1 Technology and Users

The word "technology" probably conjures up such terms as "machines," "equipment," and "hardware" in the minds of most people. When placed into the context of information processing systems, these are usually exemplified by computers, communication devices and micrographics equipment. Technology also leads many people, especially those who are not very technology-oriented, to think about prospects of ever increasing automation (or replacing humans by machines) and about what usually appears to be the all-consuming emphasis, namely greater efficiency in system operation.

However, efficiency should not be the only determining factor in assessing system improvement. Particularly in information systems such as ERIC, involving significant human interaction with machines, the effects of technology on system performance must be evaluated more comprehensively. The user-system relationships must also be taken into account [EVA-4]. This means that besides typical questions about efficiency (involving such quantitative measures as cost, volume, capacity, throughput, time) questions about effectiveness (pertaining to the more qualitative aspects of the system and its products) and also about synergism or symbiosis (dealing with characteristics of the user-technology interface, user needs and preferences and even various environmental influences) must be answered. Consequently, selected interrelationships between/among the efficiency-effectiveness-synergism considerations can lead to productivity, cost-benefit and other meaningful evaluation studies.

Although this study is not an evaluation as such of the ERIC system, its investigative nature nevertheless carries some evaluative overtones. When asking about how well ERIC would do given certain types of technological changes or innovations, therefore, it is important to have an understanding of what system testing and evaluation, when formally carried out, are all about [e.g., EVA-5]. Effects of technology can be assessed very selectively with only efficiency in mind [EVA-6] or comprehensively with interest not only in technology but also in the associated people and their interactions with the technology [EVA-7].

The main purpose of the above discussion is to convey the orientation adopted for this study: technology-based system improvements of ERIC should not merely be hypothesized and recommended in technical terms using efficiency arguments; they must also be justified with regard to psychological, sociological, management and other considerations applicable to the people (end users, intermediary users, potential users, staff, administrators, etc.) associated with ERIC. While this approach makes a study considerably more complex and difficult in nature, it also promises to generate more realistic and useful results.

2.2 Methodological Points

Because this small-scale study was not commissioned to be a formal evaluation of the ERIC system or some part thereof, methodologies for testing it, carrying out experiments on it, conducting well-structured pilot studies in conjunction with it, and other such possibilities do not apply. The objectively obtained, statistically significant evaluative data that could result from such studies are therefore not to be found in this report (except via reference to other publications). Hopefully, as will be discerned later, such well-organized, follow-up studies will be precipitated by our work.

How, then, was this investigation into technology-based improvement of ERIC, probably the first such attempt to seriously consider technological alternatives for ERIC on a global basis, actually conducted? The general approach can be characterized as follows:

1. Project organization and scheduling, in terms of major foci of attention (Section 2.4) and study priorities (Section 2.5), to assure that at least the most important alternatives would be considered during the one-year study period.

2. Information collection and compilation, given the available literature and utilizing the various NIE/ERIC and NBS resources people identified in Section 1.4.

3. Assimilation and attempted correlation of the information on the

   (a) ERIC system, on the one hand, with its operational problems and prospects, and the

   (b) Present and potentially

applicable (to ERIC) technology, on the other hand.

4. Development of profiles of pertinent information processing and communication characteristics and criteria to enable structured comparison of technological alternatives.

5. Formulation and discussion of feasible alternatives for technology-based improvements of ERIC, with the possibility of repeating the above steps as necessary.

The information collection phase, with regard to the ERIC system, was largely dependent on personal contacts and interviews. It was decided, in discussion with the NIE staff, that a questionnaire approach was not desirable. The visits and interviews produced much useful but obviously subjective material. A number of the collected thoughts and opinions about ERIC will be reflected in later parts of this report.

In addition to the five steps or phases outlined above, this investigation was necessarily also dependent on investigator knowledge, experience and even intuition. Recommendations must therefore be viewed as outcomes of investigator-controlled syntheses of available facts, opinions and conjectures. This means that the results are largely subjective in nature, representing investigator judgment or opinion. However, that subjectivity is tempered somewhat by presenting alternative configurations or solutions (as opposed to only the one deemed "best") whenever possible.

2.3 Functional Description

ERIC is a national information system which was intended to serve the following two needs of the educational community [ERI-3]: to acquire and guarantee ready access to the range of hard-to-find education literature, and to produce new information products for decision-makers and school personnel based on the volume of reports and related material.

To achieve the above-stated purposes, ERIC carries out the following broadly stated actions [ERI-4]:

1. Collects, screens, organizes and disseminates reports

2. Furnishes copies of educational documents at nominal cost

3. Acts as an archive of educational literature

4. Prepares interpretive summaries, research reviews, and bibliographies on critical topics in education

5. Services information centers throughout the country

6. Answers education information questions

But these do not reveal how and where documents are collected, copied, archived, etc.; likewise, they don't say how the other services are provided. However, answers can be elicited from a variety of descriptive materials, as indicated by the listing of items in the ERI segment of the attached bibliography.

To get a better understanding of what constitutes the ERIC network, and what is done where, reference is made to Figures 1 and 2 respectively. Figure 1 displays ERIC with emphasis on its four levels regardless of interconnections among components [ERI-5]. Of particular interest is the nationwide network of 16 clearinghouses. These clearinghouses collectively represent the primary source of input to ERIC. According to ERI-4:

> Each specializes in a different, multi-discipline, educational area. Each searches out pertinent documents-current research findings, project and technical reports, speeches and unpublished manuscripts, books, and professional journal articles. These materials are screened according to ERIC selection criteria, abstracted and indexed. all of this information is put into the ERIC computer database and announced in the ERIC reference publications.

But Figure 1 does not give enough detail about the flow of documents and products through ERIC, ultimately to be accessible to the user. It also gives no evidence of what, if any, technology is currently being employed at various nodes of the ERIC network. Figure 2 characterizes the interrelationships and it also gives general hints on the technology presently in use.

Input items are processed and dichotomized by the clearinghouses into paths for the report literature and the journal literature respectively. Aside from the miscellaneous types of equipment (e.g., on-line terminals to commercial search systems, copying machines, etc.) used in conjunction with providing services in their roles as special information centers, the clearinghouses are mainly

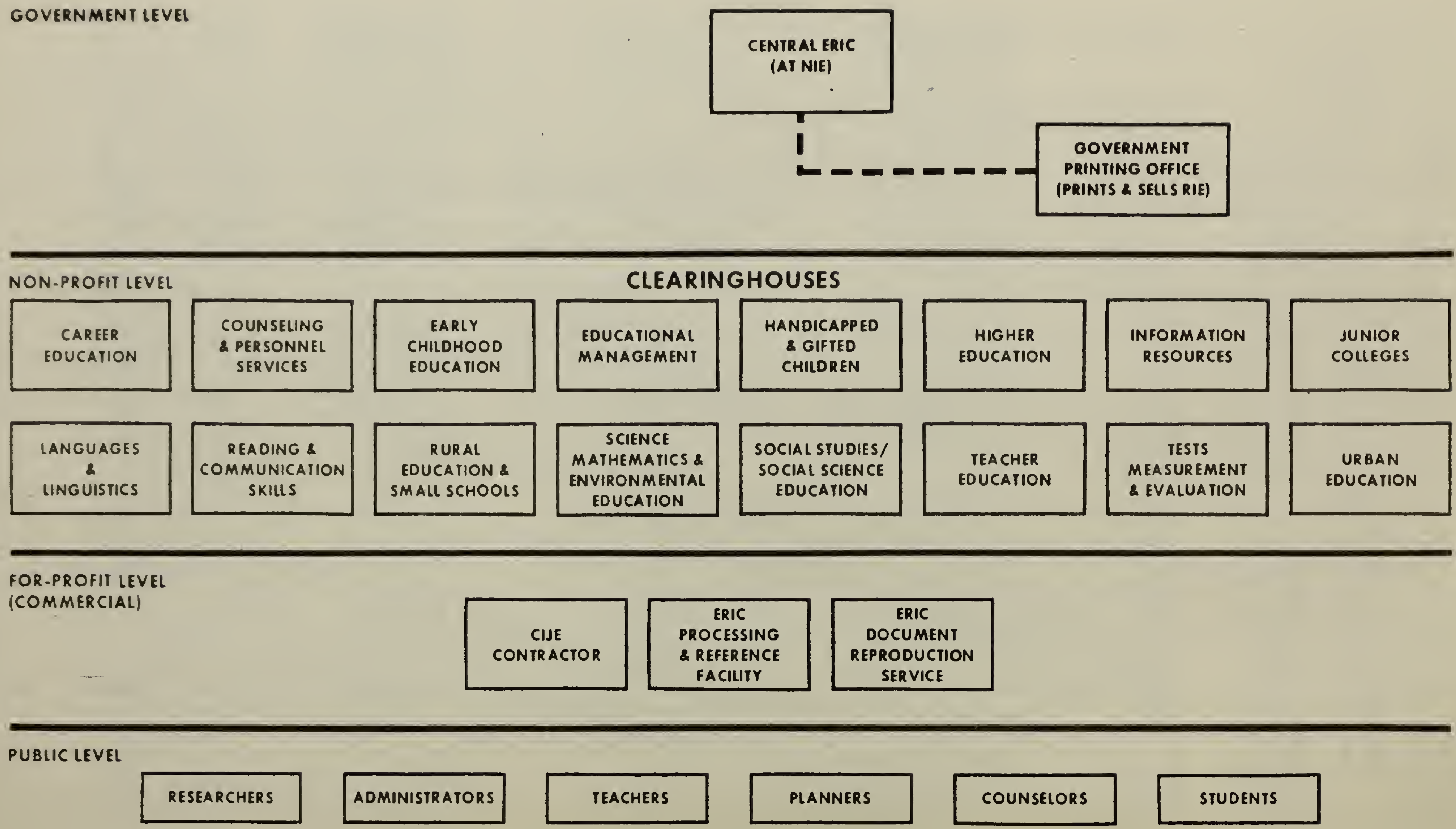

FIGURE 1. ERIC NETWORK STRUCTURE & ORGANIZATION

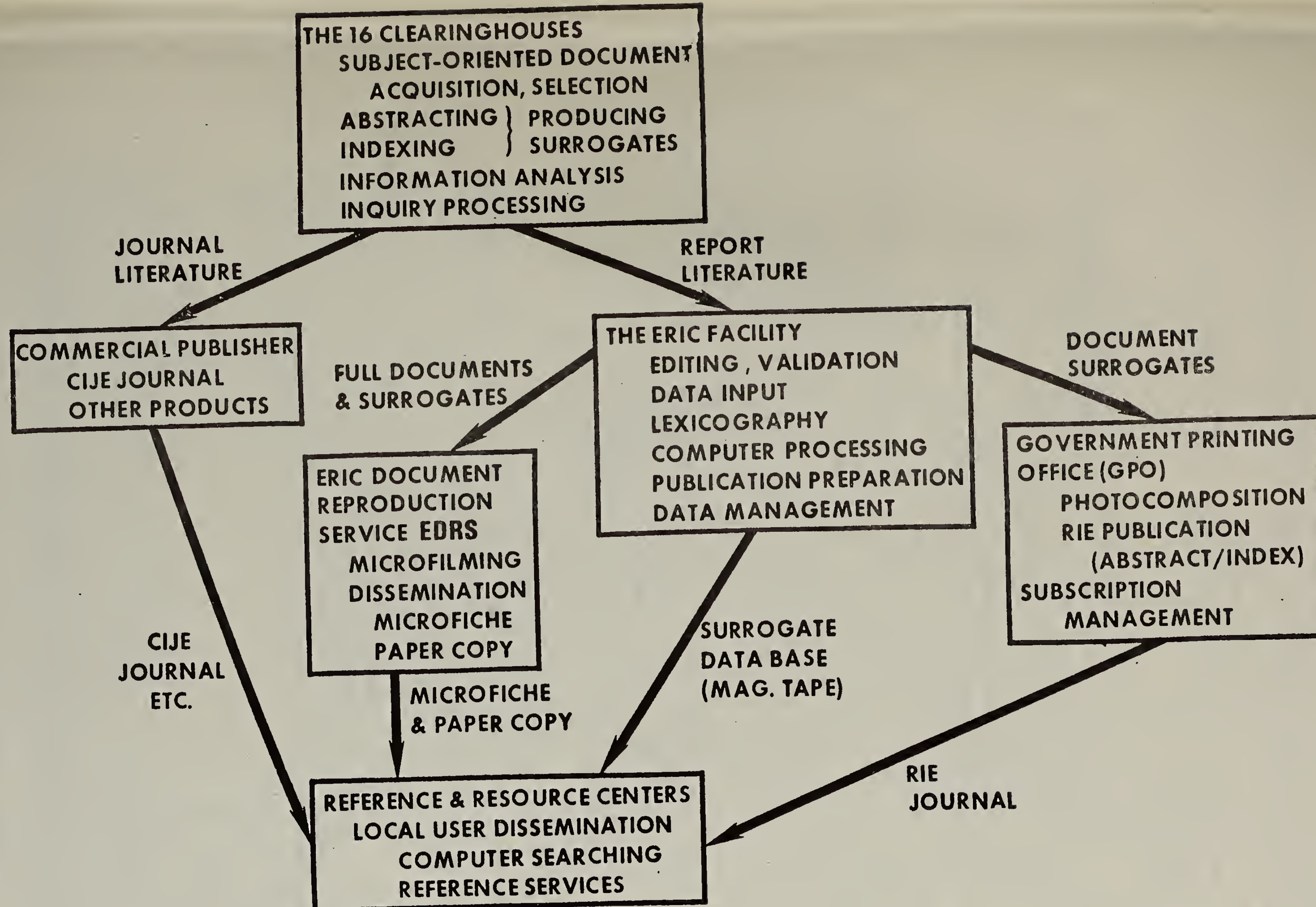

FIGURE 2. DOCUMENT/SURROGATE PROCESSING THROUGH ERIC

involved with OCR-oriented devices which allow document surrogates to be input to the database via the ERIC Facility. On the output side, they have assortments of equipment for reading and maybe printing from microfilm, besides ordinary copying machines. As will be noted later, a few clearinghouses have been involved with special efforts or experiments in using other technology, e.g., word processing computers.

The journals path of the input dichotomy (Figure 2) is handled relatively easily by forwarding the document surrogates only (no paper copies involved) to the publishing contractor who then produces the Current Index to Journals in Education (CIJE) and other spinoff publications. Our study does not concern itself with the composition and printing equipment used by the publishing companies.

On the more complicated side of the input dichotomy (see again Figure 2) is the processing of the report literature. Both the paper copies and the surrogates (on OCR-compatible forms) of documents accepted by ERIC Clearinghouses must be submitted to the Facility. The latter then edits and validates the surrogates (abstracts, index terms) and adds them to a computerized database, using OCR equiment and the computer facilities of a commercial timesharing service. As a consequence of this surrogate data processing, the abstract journal Resources in Education (RIE) is produced by the Government Printing Office (GPO) and, furthermore, the database segments are sold (on magnetic tape) to commercial providers of computerized search services and other agencies with their own computer search systems. The various local information centers can then of course have access to them.

One more branch off the Facility node (in Figure 2) remains to be discussed. The Facility must also prepare the paper copy documents themselves for filming by the ERIC Document Reproduction Service (EDRS). The latter has the capabilities to produce microfiche of all the submitted documents, and either to provide microfiche duplicates for about 680 standing-order customers or to generate paper copy reproductions of documents and microfiche duplicates in response to customer orders. This micrographics activity in ERIC represents one of its heaviest uses of technology.

2.4 Foci of Attention

Realizing that it would not be possible in this one-year study to consider all aspects of technology application to ERIC, an early requirement was to identify the major foci of attention. Figure 3 gives a diagrammatic overview of the areas which, from the investigator's viewpoint, appeared to be most critical and which promised most fruitful results in terms of technology-based improvements. As was stated in Section 1.3, ERIC was to be considered both with regard to selected components as well as its network on the whole. Corresponding topics are outlined in the following two subsections respectively.

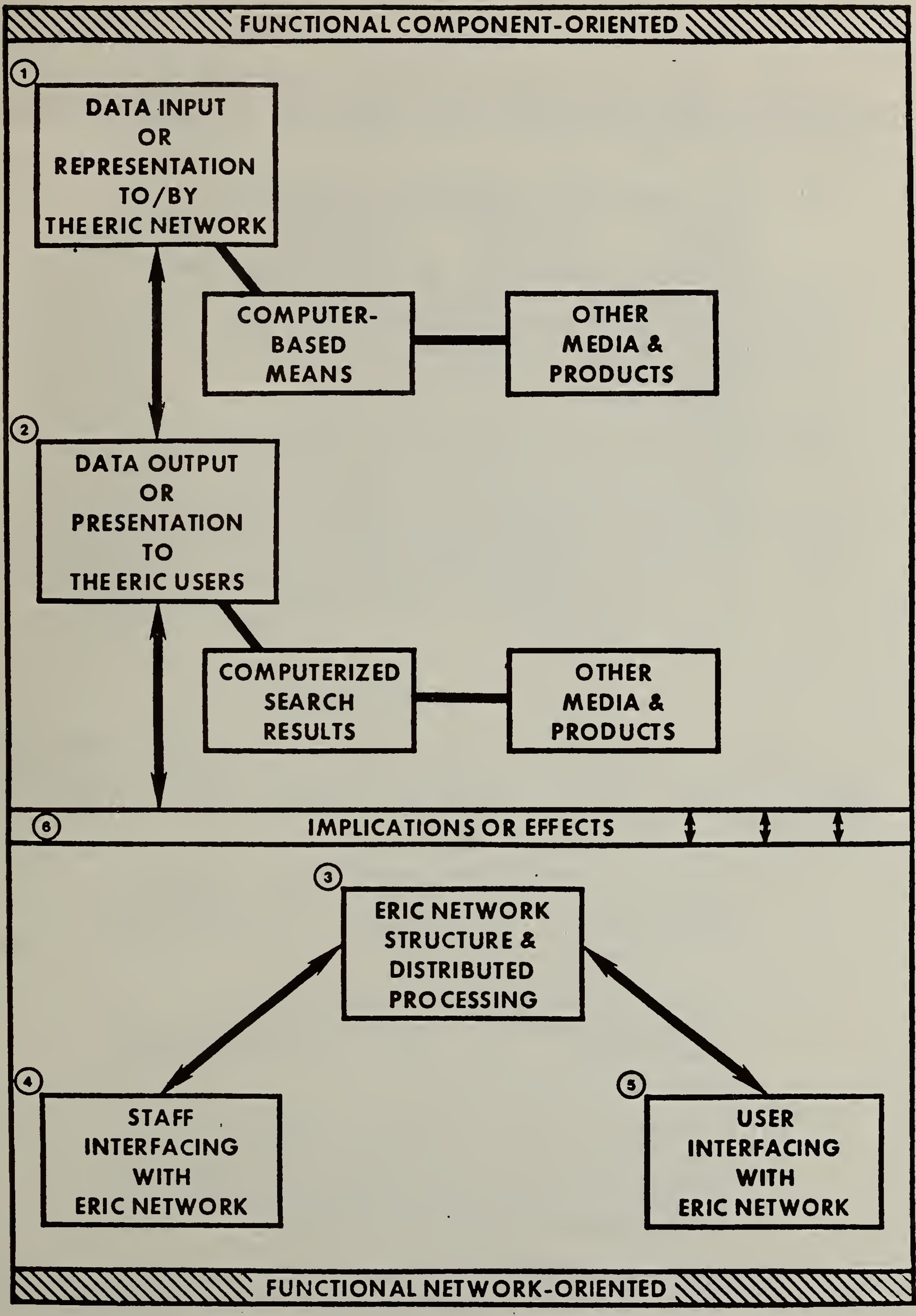

FIGURE 3. FOCI OF ATTENTION

2.4.1 System Components

With reference to the circled numbers in Figure 3, the component-oriented topics that appeared to be most relevant and critical were

(1) The means and methods for entering documents and their surrogates into the ERIC system, whether into machine-readable or other storage media. This was to encompass scrutiny of ERIC microfilming of documents, on one hand, and various computer-oriented techniques (e.g., OCR and word processing), on the other hand.

(2) The means and methods for outputting or presenting (to ERIC users) those data that were somehow input to the system. Thus this topic is of course intimately related to or dependent on topic (1). However, the emphasis here was to be on the technological user-system interface which presents or displays the information.

2.4.2 Total System

After considering the above-specified functional components of ERIC, emphasis was to shift to the ERIC network on the whole. Selected topics were, again with reference to Figure 3:

(3) Possibly complete restructuring of ERIC based on applications of computer networking, distributed processing, minicomputers, etc.

(4) Under the umbrella of topic (3), technology-facilitated communication and coordination of ERIC clearinghouses, staff and management.

(5) Likewise in the context of studying topic (3), the means and methods of interfacing users to the ERIC network, with the objective of greater satisfaction of user needs/expectations/preferences.

Finally, throughout the study we had to be cognizant of the fact that the whole is dependent on its component parts:

(6) Implications or effects of topics (1) and (2) on (3) through (5), and vice versa.

2.5 Study Priorities

After correspondence and consultation with NIE on the foci of attention outlined above, it was determined that NIE considered the first two interdependent topics, namely,

(1) Data input or representation, and

(2) Data output or presentation,

particularly with emphasis on the use of microfiche, to be of priority interest. Some aspects of topic (5) dealing with the ERIC user interface were indicated as being also of considerable interest. Finally, the remaining, above-outlined topics, possibly involving major restructuring of the ERIC network, although not to be ignored were to be viewed and treated as secondary in importance as far as NIE was concerned.

While this report reflects the NIE-indicated study priorities, it is nevertheless an attempt to be reasonably comprehensive in spite of the obvious constraints (in time and manpower available) on this project.

3. COMPONENT-ORIENTED CONSIDERATIONS

In a large system, it is often desirable or even necessary to scrutinize selected parts or components either due to observed performance problems which they have engendered or perhaps because improved means for accomplishing those component functions have become available. The investigators must, of course, be sure to realize that modification of a part generally carries effects or implications for the whole.

This section presents the results of our study with regard to the top-priority functional components of data input/representation and data output/presentation. Section 4 then incorporates and envelopes this material by looking at the ERIC network on the whole.

3.1 Data Input or Representation

Any information system must have facilities for entering or inputting whatever information (or data) it is to encompass. In the process, it must employ the transformation or translation techniques which are suitable for the available system-internal data representation formats and media. This data input and representation function is discussed in the following subsections with respect to generally applicable characteristics, different technological means and media, and comparison of available alternatives.

3.1.1 Input Characteristics and Criteria

To consider technological alternatives for handling the data input and representation function, the characteristics of those input data and the criteria for processing them must be understood. It is, therefore, important to first define and distinguish such characteristics and criteria. In so doing, this section adopts special identifying labels for ease of reference and later use in the tabulated comparisons of technological alternatives.

3.1.1.1 Data Types

The types of data that may, in general, be entered into an information system can be categorized as follows, tying them into the most prominent and suitable sensory faculties of human users:

D1. Visual data

(1) Textual or alphanumeric

(a) Full text of any documents (papers, reports, procedures, etc.)

(b) Surrogates of such documents (citations, index terms, abstracts)

(2) Statistical or numeric

(3) Graphic, diagrammatic and pictorial

(4) Combination of above

D2. Audio data (e.g., speech, music)

D3. Tactile data (e.g., in Braille)

D4. Combinations of above

(1) Audiovisual

(2) Other

The ERIC system is presently almost exclusively oriented to processing visual data (D1) which are textual and of the printed and/or microfilmed varieties. The so-called nonprint items, such as films, filmstrips, videotapes, audio recordings, etc., can not as yet be input and processed.

From the human sensory standpoint, the above categorization can be interpreted as substantially independent of the media employed. In a way, that is what information technology is about: the maintenance of the identity of a type of data (or information) such that it is recreatable or reproducible (ideally) without any loss of accuracy or even aesthetic appeal. In addition, it may be possible to transform the information using technology in order to enhance it and/or complement it with other types of information (e.g., in multi-media representations).

Realistically, each of the above categories, of course, becomes associated with the most prominent current media available. For example, textual data immediately suggest paper documents or microfilm or computer storage. But which is most appropriate? Likewise, which technological media for input and representation are available for each of the other above-categorized types of data and why is one better than another? To pursue such questions further, additional characteristic guidelines are developed in the next subsections.

3.1.1.2 Data Quantities

One of the determining factors in deciding what technology to use to input data into an information system is the sheer quantity or density of the data. We know that the full text of some document may be several hundred times as voluminous as a surrogate, such as its abstract. This obviously has implications on how much input processing time and effort must be expended on the two different levels of document representation respectively. It also has a bearing on the pure storage capacity required, on whatever medium, to accommodate the data. In addition, the rate of flow of such documents into the system must be considered to gauge the collective effects.

Similar statements can be made about the other data categories listed in the previous section. In some of them, there are additional complications such as their conversion from an analog form of data (e.g., a photograph or an audio recording) to a digitized counterpart. The resulting data volume (depending on sampling techniques employed) may be substantially greater and less compact. It may also, of course, be less accurate than the source.

In order to arrive at some general guidelines indicating levels of data quantity or volume of relevance to the ERIC system, assume that a typical report consists of the equivalent of 100 pages, 60 lines per page and 100 alphanumeric characters per line. Such a report would then amount to 600,000 characters resulting in the need for approximately 120,000 words (on a 36-bit computer) or 150,000 words (on a 32-bit computer) of storage space. This rough approximation (not counting overhead) can be used further to estimate the requirements of handling a flow of such documents over a period of time. For example, assuming that ERIC inputs about 1200 such reports (for RIE) each month, input processing would involve about three-quarters of a billion characters and in the neighborhood of a 150 to 180 million words of computer storage. We shall term such input volume "high level."

On the other hand, a bibliographic citation of that same 100-page document, along with descriptors and abstract, may typically consist of 60 lines of 50 characters each. Its 3000 characters require relatively little storage, ranging from 600 to 750 computer words. Of course the monthly input of 1200 such items still requires from three-fourths to nearly one million words. We shall consider that input volume to be relatively "low level."

Thirdly, the other categories involving graphic, pictorial and audio data are much more variable in terms of data volume and hence less easily categorized. As is well known, "a picture is worth a thousand words" and in fact one digitized photograph may well require millions of point data (identifying shading, color, etc.) to be stored. Hence, the per-item-volume for such data must generally be rated very high, but the number of such items flowing into the system could conceivably be quite low. Hence, we will consider this input volume to be "special."

To summarize for purposes of later reference, the data input volumes are simply classified as:

V1. High volume

V2. Low volume

V3. Special volume

3.1.1.3 Data Purposes

The decision on which technological medium to use for a given data category with an associated volume should also be dependent on the purpose(s) of the data being entered into the system to begin with.

It would be poor planning indeed to input a high-quality data stream into a perhaps costly technological medium without justifying that input in terms of intended processing purposes and uses of the data. For example, if a full-text document is only to be reproducible but not searchable (for answers to queries) in its full text form, it makes sense to consider a medium which is less flexible and costly but serves the purpose adequately. However, the consequences of such a decision, in terms of precluding the future searchability of the database, must be fully acknowledged.

Similar questions apply to the other data categories. Statistical data may be simply collected for purposes of reproduction (analogous to the alphanumeric case), maybe in some established tabular format. It is quite a different matter if those data are to be analyzable by computer. This requires conversion to the internal representation which is appropriate for computer processing.

Another kind of data purpose which warrants identification is transformation to some alternative form or view of the represented information. This is exemplified by graphic data which may be structured for transformation using computer graphics. Similar effects, although to differing degrees, could result in processing pictures or photographs (by means of sophisticated digitization and pattern recognition techniques) as well as audio data (by means of advanced speech recognition/analysis and music digitization/recomposition methods).

In summary, the following three major purposes of inputting and storing data in an information system should be recognized:

P1. Data (Item) Reproduction or Copying

P2. Data Structuring, Searching and Analysis

P3 Data Transformation or Modification

Again, the associated labels are employed in later sections to facilitate referencing and comparison within the general framework of significant factors being developed.

3.1.1.4 Performance Criteria

Having dealt with the questions of what type of data is to be input, how much of it, and what the purpose of the input data is to be, we can ask about how fast and how well the suitable technological alternatives available can process the input. But, in order to try to respond to the latter, at least general performance-related guidelines are necessary. Using the efficiency-effectiveness-synergism trichotomy mentioned in Section 2.1, management questions about technology-based performance can be categorized as follows:

E1. Efficiency:

What is the rate of input processing?

How much does the processing cost?

E2. Effectiveness:

How well is the data purpose met?

E3. Synergism:

How satisfied are the information users?

The above-stated questions are indicative of those which are likely to be most important to persons considering system changes. Their priorities may be such, however, that the cost question may predominate the rest. In a formal evaluation of a system, questions like those stated above can be interpreted as performance criteria for which the evaluation team must collect various kinds of objective and subjective information, by means of appropriate measurement techniques, questionnaires, etc. Consequently, answers to the questions must be obtained through meaningful presentation, interpretation and use of the collected information.

For purposes of this study which is not a system evaluation as such, the above-stated performance criteria are also employed, but only to support general comparison of various technological alternatives. Such comparisons are made in several sections of this report.

3.1.1.5 Framework of Factors

Given the characteristics which were broadly defined in the previous subsections, our investigation of technology-based improvement of data input and representation in the ERIC system can be encapsulated with reference to Table 1 as follows:

(1) With a number of different types of data to be input, presently and perhaps in the future, as a subset of
    Data Types D1, D2, D3 and D4
    (Section 3.1.1.1)

(2) And with different quantities of such data to be processed, given
    Data Volumes V1, V2 and V3
    (Section 3.1.1.2)

(3) And having different reasons or purposes for inputting such data into the system in the first place, namely
    Data Purposes P1, P2 and P3 (Section 3.1.1.3)

(4) Then, if the desirable levels of performance can be specified somehow (preferably by management), in terms of
    Performance Criteria E1, E2 and E3 (Section 3.1.1.4)

(5) It should be possible to identify technological means and methods which are being used or could be used to accommodate different data input profiles, i.e.,
    D-V-P (Data Type-Volume-Purpose) combinations,
    with regard to required or desired performance criteria E.

With reference to this framework of factors, which is intended to provide some structure to our considerations of what ERIC is doing and can do with data input technology, the following sections discuss the major existing and potential alternatives.

3.1.2 Microfilm and Fiche

The terminology employed in the area of micrographics, as in other specialty areas, is often misleading or confusing [MFF-1]. This is partly due to the growth of this field which has led to new and perhaps unanticipated uses or packagings of the technology, resulting in some overlapping if not altogether conflicting meanings of terms. However, the literature includes good clarifying reports [e.g., MFF-2,3,4].

Table 1. Characteristics and Criteria for Investigating Data Input Technology

DATA INPUT CHARACTERISTICS:	Label
Type of Data	
Visual Data	D1
Textual or Alphanumeric	D1(1)
Full Text	D1(1)(a)
Surrogate	D1(1)(b)
Statistical or Numeric	D1(2)
Graphic, Diagrammatic, Pictorial	D1(3)
Combination of above	D1(4)
Audio Data	D2
Tactile Data	D3
Combinations of above	D4
Volume of Data	
High Volume	V1
Low Volume	V2
Special (Irregular) Volume	V3
Purpose of Data Input	
Data (Item) Reproduction or Copying	P1
Data Structuring, Searching and Analysis	P2
Data Transformation or Modification	P3
INPUT PERFORMANCE CRITERIA	
Efficiency	E1
I/O Processing Rate	E1(1)
I/O Processing Cost	E1(2)
Effectiveness	E2
Quality of Results (w.r.t. Purpose)	
Synergism	E3
User Satisfaction	

In this section, we present the micrographics technology as one important means for inputting and representing data in the ERIC system. Included are assessments of various aspects of its current use as well as indications of its potential for the future.

3.1.2.1 Prominence in ERIC

Without question, microforms and, more specifically, microfiche play a very prominent role in the currently existing ERIC system (see also Figure 2). About 1,200 paper copies of reports flowing into the system monthly are microfilmed. Because approximately 680 organizations (including around 50 in foreign countries) have standing orders for complete ERIC microfiche sets, ERIC delivers about 21,000 microfiche cards to each such subscriber every year.

This substantial use of micrographics, for representing and maintaining the fugitive, non-journal reports of interest to the education community, is considered by many people to be the most visible and stabilizing element of the ERIC system. Among the questions to be answered, however, are whether that stabilizing influence should be retained essentially as it exists or whether it should be significantly modified and/or complemented by other technological means.

3.1.2.2 Pros and Cons

In accordance with the characteristics defined in Section 3.1.1, microfilm can be categorized as particularly suitable for Visual data (D1), high volume of input (V1), with the purpose of reproducing or copying the data (P1) for ultimate viewing. In ERIC, the visual type of data involved are primarily textual or alphanumeric in nature.

What about the performance of microfilm technology? In general, its efficiency (E1) is quite favorable. Rate of input processing is of course considerable, especially when presented in terms of number of characters "input" or filmed per unit time. Beyond some preparatory work (e.g., pagination) required to set up the document pages for filming, the input processing rate is only subject to the camera speed itself.

The other efficiency-related factor, namely cost, is also an attractive feature of microfilm. Relatively low cost for high-volume input processing, in comparison with other technological alternatives such as computers, was clearly a major influencing force in gaining its status in ERIC. Yet, that statement must now be carefully qualified by pointing out that the above-specified purpose (P1) in microfilming documents for ERIC is, after all, quite restrictive. It does not allow for any automatic analysis or searching of the data stored on the individual microfiche cards themselves.

Thus, it becomes important in our investigation to separate out what can be done well with current microfilm technology from what it cannot do. With respect to the former, the remainder of this "microfilm and fiche" section is devoted to discussing our assessments of micrographics as used in the ERIC system and as it could perhaps be improved. This means that, for the useful but restrictive purpose (namely P1) that microfilm is able to serve with relatively good efficiency (see E1 criteria), we want to consider it also from the standpoints of effectiveness criteria (E2) as well as synergism criteria (E3). It should be reemphasized here that our present concern is with data input or representation. The complementary side, namely data output or presentation (covered in Section 3.2), will of course present additional effectiveness and synergism considerations as they apply directly to the users.

Those data input purposes (namely P2 and P3) which are not served well by micrographics will be dealt with separately in subsequent sections on computer-based and computer-microfilm composite technologies.

3.1.2.3 Guidelines to Quality

If a paper copy document is to be photographed or, more specifically, microfilmed, how is it done and, more importantly, how is it done with high-quality and cost-effective results? It is not the intention in this report to present detailed descriptions of the microfilming process. The rather extensive literature covering this area (see sample set in MFF segment of adjoining bibliography) can be easily referenced for technical discussions of specific features.

In the 1960's many people were still enamoured by how microphotography worked and how much information could be stored on microfilm [MFF-5]. Actually, it was reasonably well developed by then, and ERIC, which was started in the late 1960's, saw fit to adopt microfilm as an integral part of the system. But over the years, the continuing issues surrounding how to employ microforms properly in information systems [MFF-6] and how to improve the techniques for microfilming [e.g., MFF-7] were discussed and debated. As a result, various advancements were indeed made.

Aside from having questions on how to choose from among a great variety of sizes, forms and shapes of microforms, and besides having any remaining concerns about related standards, users of microfilm technology have become increasingly sensitized to problems with quality of microimages produced. A number of significant factors must be taken into account in order to ascertain an index of quality for a given micro-recording system. These range from the readability requirement (e.g., in terms of character size or height) to the loss resulting from duplicating microfilm and to the resolving power requirements given specified reduction ratios [MFF-8 and 9].

Recognizing that such technical quality guidelines do exist, this investigation considered what microfilm technology is specifically being used in the ERIC system, how it compares with the state-of-the-art, and whether any improvements may be indicated. As is described in the next several sections, our investigative procedure and results obviated any need to make detailed determinations of quality indexes for ERIC-used microfilming equipment, even if that had been feasible.

3.1.2.4 ERIC Document Reproduction Service

The microfilming for ERIC is carried out by a contractor. The ERIC Document Reproduction Service (EDRS) is, therefore, not an in-house department of ERIC as such, although the document preparation work which feeds into EDRS is performed at the Facility (see Figure 2). Consistent with the aforementioned fact that this study was not to be an evaluation of ERIC, it was deemed (in consultation with NIE) to be beyond the study scope to attempt any kind of experimental testing of the microfilm technology employed by the EDRS contractor. Any extensive observation of the EDRS daily operations was also precluded. That would have been both too disruptive and time-consuming. Hence, towards arriving at our assessments of technology use in EDRS, the following means or types of evidence were employed:

(1) Several informal visits were made to EDRS to discuss the operations with the manager, tour the facilities and learn about the repertoire of microfilming and related equipment in use. A draft copy of a document describing the operations (including quality control) was also obtained [MFF-10].

(2) Visits were conducted to three other selected microfilm service centers for purposes of generally comparing their facilities and operations against EDRS. Those three centers had been identified as illustrative production shops.

(3) Summaries of results of a 13-month complete inventory (period July 1977 to July 1978) of the ERIC microfiche collection, in addition to a partial inventory of four selected segments of the file created by previous contractors, were made available to this project by the Facility staff.

(4) A publication entitled "Document Reproducibility Guidelines," compiled by staff members of the Facility and EDRS for purposes of guiding those involved in deciding on inputting reports to ERIC, was sent to us for review late in 1978. The sample copies displayed in that document were produced by the EDRS contractor and provide some further evidence on the quality of equipment in use.

The latter three of the above-specified sources of information about EDRS will be covered in the next three sections respectively. It should be pointed out once more that we are still emphasizing the inputting of documents into ERIC to be microfilmed. Further evidence on EDRS technology and the related problems as perceived by ERIC users and information specialists will be discussed in consideration of ERIC data output or presentation.

3.1.2.5 EDRS Compared With Others

Besides EDRS itself, three carefully selected microfilm services in the Washington, D.C. area were visited and toured. The three were chosen as being representative of an "outstanding," a "very good," and a "fair" service respectively. This subjective rating was made based on investigator experience* with those organizations coupled with their reputations. It was to encompass both the quality of their equipment as well as their operations on the whole. The visits certainly confirmed those ratings.

In direct comparison with the three other representative services, it was concluded that the microfilm technology and its use by EDRS can be judged as most similar to the intermediate or "very good" service. EDRS seems to be running a respectable operation around a solid selection of filming and related equipment (including two high-speed step and repeat cameras).

It is important to note, however, that unlike some other microform production facilities, EDRS processes whatever the ERIC facility sends. That is to say, judgments on whether or not a document is of adequate typographic quality (i.e., type size, contrast, etc.) are not made by EDRS. It simply receives the paper copy documents already selected, prepared and categorized by level (see next section), along with the document resume master (magnetic) tapes, and then films the documents and produces the fiche titles from punched paper tape (after titles are read from magnetic tape and converted). In addition, it then produces, upon demand, blowback paper copies from acceptably

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*The principal investigator was accompanied on these visits by Mr. Thomas Bagg of the National Bureau of Standards.

categorized microfilm.

What the above means is that EDRS is, on the one hand, in the fortunate position of being able to exert their best skills to apply good microfilm technology as effectively as possible to whatever documents are already preselected for them. As evidenced in the next section, concerned with tallied error rates, some improvements are indicated. However, on the other hand, EDRS is also in the unfortunate position of being blamed for problems, especially associated with poor quality input documents, over which it has no control except via a monthly problem report which can serve to influence future input. In addition, ERIC is said to have an "archival" responsibility which technically should mean the maintenance (perhaps in some vault) of all input documents (or microfiche thereof) but which in practice means maintenance as well as use of the document collection. As a result, the current EDRS contractor must also bear the burden of complaints which are actually attributable to many lesser quality microfiche generated by previous contractor(s).

3.1.2.6 Inventory Results

For a period of thirteen months, the microfiche produced by the current EDRS contractor were inventoried and quality checked by the Facility staff. We were assured that this was done on a fair, impartial basis. One of the following four qualitative scores was thereby assigned to each microfiche:

1. No Problems - Good Fiche

2. Minor Problems - Acceptable Fiche

3. Several Problems - Marginal Fiche

4. Serious Problems - Unacceptable Fiche

With the total number of monthly RIE accessions ranging from a minimum of 1,081 to a maximum of 1,590 during that 13-month trial period, the monthly percentages of all items which received above-indicated scores of either 3 or 4 (collectively) averaged at about 2.3%. This figure excludes the Level III documents which are not actually made available, as discussed in the next section.

In response to each monthly inventory and quality check summary, EDRS provided detailed explanations of identified problem cases. An assortment of difficulties can be elicited from those responses, ranging from camera malfunctions to human operator error. This interchange between the ERIC Facility and EDRS is itself a constructive, worthwhile step which surely leads to greater sensitivity on both sides to existing problems and to their alleviation if not total elimination.

However, it must be reported furthermore that many of the apparent errors detected in the EDRS-produced microfiche were actually due to the input documents themselves and other problems beyond the control of EDRS. This matter will be pursued further in the next section. In the meantime, the approximately 2% average monthly error rate which can be reduced further given many plausible explanations by EDRS, must be regarded as a reasonably respectable performance under the circumstances of running a production shop. This judgment is consistent with indications given by managers of other high-caliber microfilming services.

3.1.2.7 Input Documents

Since this investigation found the EDRS microfilm technology and its related, supportive equipment to be representative of the state-of-the-art, and since the recent use of that technology appears to exhibit a respectable level of operation in terms of low error rate, then what seem to be the main difficulties which are at the root of criticisms vented about EDRS products? These difficulties must be dichotomized into document input (to ERIC) and EDRS product output (to ERIC users). The latter is discussed in the next major section.

With regard to documents input, ERIC is categorizing the source documents according to the following three levels:

1. Level I: Reproducibility of the document is judged to be good enough so that it should be legible both on a microfiche reader and in blowback, paper-copy form. Users can therefore get them from ERIC in either microfiche or paper copy. In addition, these documents are either not copyrighted or a release has been obtained for them for use within the ERIC system.

2. Level II: The document is judged to be only readable on microfiche but is of unacceptable quality for paper-copy blowback; alternately or in addition, this category may include copyrighted documents for which only a limited microfiche release has been obtained. Thus, these documents are only available in microfiche form.

3. Level III: The document is either of unsatisfactory quality for any form of reproduction and/or it is restricted via copyright. Hence, it is not available from EDRS, although the publication source is cited. Present Level III input amounts to about 5%, primarily restricted by

copyright.

The main problem with such categorization according to document reproducibility (ignoring the copyright restrictions for our purposes here) are who will make the judgments and what criteria or guidelines will be used for making them. The old computer-oriented saying of "garbage in, garbage out" applies with microfilming as it does with computer input.

If EDRS is asked to microfilm a Level II document which is actually of very poor typographic quality, even the most beautiful currently available filming and reproduction technology is strictly limited as to what can be done. Aside from some well-known enhancement techniques (.e.g, using office copiers), automatic means for "creating something out of nothing" do not exist. Either another technological approach or perhaps non-technological methods (administrative in nature) may have to be called upon.

It follows therefore that the decision by a well-intentioned person to enter a document into ERIC which is of significant content but of poor typographic quality may generate a practically illegible microfiche and/or blowback paper copy and consequently cause user complaints. The reputation of ERIC and particularly EDRS (perhaps totally undeservedly) is thereby , of course, not enhanced.

So what can be done, if anything, to counteract this problem? In selected cases, perhaps more could be done in terms of (costly) human touch-up or retyping and tracing of certain significant-content but poor-quality source documents. Other than retyping and short of turning to an alternate, more costly computer-oriented technology (discussed in Section 3.1.1), the emphasis must be on controlling the input of documents to ERIC.

ERIC is, therefore, to be commended for having expended a considerable effort towards producing guidelines intended to support that objective.

3.1.2.8 Reproducibility Guidelines

In recognition of the inconsistencies that have existed in decision-making on which of the reports or so-called fugitive documents should be included in ERIC, and at what level (see previous section), with regard to reproducibility characteristics, a special guidelines document has been prepared by ERIC [MFF-11].

This document is not concerned with subject content but rather only with reproducibility, by considering a number of significant factors which affect contrast and therefore document readability upon reproduction. Among the independent variables described are various typographic factors (point size of characters, line widths or boldness of face, character density, and font variations) in addition to other factors such as background density and colored printing. The effects of the interactions of several of these variables are then portrayed. Finally, the results of defective type, use of office copying machines and inclusion of certain graphics (e.g., tables, drawings, photographs) are demonstrated. All of these are backed up by means of illustrative examples of original source items exhibiting the factors of concern. The examples were actually reproduced by EDRS. They constitute the bulk of this publication although quite a few samples are as yet not included [MFF-11].

These reproducibility guidelines are unquestionably much needed and should prove to be useful in controlling the typographic quality of input documents. However, not all ERIC-associated personnel are happy with the guidelines and furthermore, as summarized in the next section, a few improvements or corrections to the guidelines are recommended.

3.1.2.9 Potential Improvements

For the type of data (D1), quantity of such data (V1) and purpose (P1) intended to be served by the microfilming and related equipment in use at the EDRS, it must be said that the state-of-the-art technology is there. Some improvements could of course be made, for example, in perhaps achieving a slight increment in camera speed or by replacing the paper-tape input (for fiche titles) with on-line terminal input. However, it is doubtful that such particular improvements would be worth the cost. Another change that might be considered is switching from the use of vesicular to diazo film, particularly for those copies to be used to make contact prints or duplicates. The resulting quality would probably be better. However, the relatively small cost difference (if any) may be viewed as significant enough to stay with vesicular.

If the technology is good enough, then what might be improved in terms of proper use or quality control of that technology, and, lastly, what can be done about improving the quality of input documents which that technology must contend with?

With regard to use and quality control, our brief glimpses of the EDRS facilities and the previously described inventory results would suggest that the staff know what they are doing. Obviously, it must be and was acknowledged that human errors do occur and can be minimized by means of the usual management-recognized incentives, quality control measures and other policies. However, more thorough quality control could be undertaken by EDRS with the usual increase in operational costs. For example, a greater number of fiche could be density-checked. Another more costly possibility would be to have an organizationally distinct quality control staff group inspect and qualify each piece of equipment before its daily use. Again, given the purpose of the EDRS operation, that type of control might be excessive. This is not to say that clearly defined criteria for declaring the equipment operational should not exist and be strictly adhered to by EDRS.

What appears to be of far greater importance to ERIC is the proper control of documents flowing into the system. This returns us firstly to the Document Reproducibility Guidelines [MFF-11] described earlier. Several improvements or corrections to these guidelines should be indicated.* Page numbers cited refer to those in the Guidelines.

1. The samples should of course be completed and the microfiche of the guidelines, promised on page 4, should in fact be included in a pocket of the back cover.

2. The term "point size" is used to indicate height of characters (on page 5 and in other places). Unfortunately, point size is only an approximation of the actual character size. In many instances a character with a smaller point size of one type face is larger than one with a larger point size designation. Point size refers to the old slug or type body size and is really the distance between the lines of type. Thus, on page 7 of the guidelines where the type size of the print of that page is said to be 9 point, it is really larger, approximately 12 point.

3. With regard to the correctly stated use of an office copier (page 10) for purposes of testing the original as to its potential for generating good microcopy, the user of the guidelines should furthermore be informed that the photocopying process itself is a common technique for possibly improving a low-contrast original document. Another good use of office copiers is pointed out as a remedial action on page 23. However, the copying technique in general may or may not lead to enhancement.

4. The choice of the word "holograph" on page 10 is unfortunate in that it is used with reference to its archaic meaning, namely being handwritten. Holographs have a different meaning in today's

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*These suggestions resulted primarily from a review made by Mr. Thomas Bagg of the National Bureau of Standards.

literature [e.g., ORT-5].

5. The "Quality Index" method which was referred to previously [MFF-8 and 9] might be considered as a most satisfactory technique for judging typographic quality with regard to character size.

Finally, it must be acknowledged that aside from suggested improvements of the guidelines for judging document reproducibility, there have already been some strong objections raised to those guidelines. Some people associated with ERIC consider them as far too restrictive, eliminating many of the very valuable items which really should be in the ERIC file but which were possibly never intended by their authors and typographic preparers to end up in ERIC.

That presents a true dilemma: on one hand trying to improve the quality of the ERIC microfiche file, largely in response to user complaints; on the other hand, including items of very poor typographic quality because of their substantive value to the education community. As was stated before, microfilm technology cannot perform miracles on some faint, unclear, carelessly prepared original report or perhaps a poor office copy of it. Hence, one further improvement relates to administrative and technical attention to how to prepare documents in the first place.

The published "Document Reproducibility Guidelines" really address the question of whether a given document, already produced and on hand, is typographically acceptable to ERIC. NIE/ERIC should consider also the establishment of guidelines for the preparation of materials [MFF-12], thereby obviating the reproducibility guidelines in many cases. One such effort can already be cited [MFF-13]. Any guidelines must of course be suitably backed with documentation and publicity mechanisms, including the incentive of entering documents into the ERIC system. Several other existing guidelines for preparing material for micropublishing could be used as models [MFF-14, 15, 16]. ERIC would, of course, have to tailor such guidelines to its own particular needs.

Even if such additional guidelines were produced, publicized and distributed, surely there would still be many documents generated which by content should be in ERIC but whose preparers were not informed or did not care about minimally acceptable typographic quality. (Most fugitive documents are presently not specifically prepared for ERIC.) What then? Then, as is restated in the data output section of this report, there should be a clearly and explicitly identified category of important but poor quality documents available through ERIC, leaving no doubt in the user's or viewer's mind as to where the blame of the poor quality lies. Alternatively, if the document is important enough, it should be retyped or, perhaps, processed via another kind of technology.

3.1.2.10 Future Prospects

Is micrographics or microimagery here to stay? Certainly, as might be expected, the related literature claims that it is [e.g., MFF-17, 18, 19]. Generally speaking, we also agree. However, we would suggest that in order to enhance the purposes of micrographics (beyond the previously identified P1) and render it more flexible in an information system environment, it is likely within the next decade to be much more coupled with or complemented by computer technology. More will be said about this in later sections. ERIC management should anticipate such developments in looking towards future improvements of the ERIC system.

3.1.3 Computer-Based Means

Having dealt with microfilm technology as one major means for inputting and representing data in the ERIC system, we must ask about other existing possibilities. Again, the characteristics and criteria portrayed in Section 3.1.1 will be referenced for purposes of facilitating comparisons between technologies and their uses.

3.1.3.1 Range of Possibilities

If the data of a certain type (e.g., D1) are already on a particular medium, namely an ERIC paper copy (printed page) report or a surrogate of it, the range of possibilities for inputting those data into some technological medium for minimal purposes of data copying or reproduction (i.e., P1) can be portrayed using the following dichotomy:

1. Technological means for eliciting the data <u>directly from the source:</u>

    (a) Use of office copiers on the source documents--an alternative which we are not pursuing further with regard to the ERIC production requirements in general, but which is, of course, acknowledged to serve many useful (preferably limited data volume) needs, including the previously mentioned remedial work for document input to microfilming.

    (b) Microfilming of the source documents --the important means discussed at length in Section 3.1.2.

(c) Facsimile representation, transmission and reproduction of a source document--a special communications-based method of "copying" data, to be discussed again later (Section 4.1.2).

(d) Optical recognition of the source document--an alternative requiring a technology capable of identifying the alphanumeric characters (in the case of ERIC's textual data) and converting them to computer-compatible code in some computer storage medium. So-called OCR as well as prospective holographic techniques [ORT-4] apply. Some form of reproduction can then take place under computer control.

2. Technological means for getting the data <u>indirectly from the source:</u>

(a) Keypunching or keying of data from source documents into some computer-readable medium (e.g., cards, papertape)--a well-known alternative which we will not consider further.

(b) Retyping or keying of source document into a typographic format/form which is optically recognizable and then transformable into computer-compatible code--an alternative similar to (1-d) above except that it requires the intermediate preparatory retyping of the text.

(c) Retyping or keying of source document directly into computer-based storage--the alternative that involves immediate user-computer interaction, thereby eliminating any intermediate automtic character recognition device.

Another major alternative should be mentioned at this point. It is based on the capabilities of alternative (2-c) above, but it involves the actual preparation of documents on a computer-based medium to begin with. Thus the "original" source document would not have to be optically recognizable (as required by both (1-d) and (2-b) above).

It would already be in computer-internal representation as opposed to paper-copy form. It, therefore, could obviate alternative (1-b) above, although it could be coupled with computer-output microfilm (see Section 3.1.4) and, hence, retain any benefits of the latter.

The following several sections are dedicated to the computer-oriented alternatives suggested above. They should confirm our position that we do not simplistically recommend that all types of data input are to be "computerized." Instead, we must continue to relate to the combinations of characteristics (summarized in Table 1) of data type (D1, D2, D3), data volume (V1, V2, V3) and data purpose (P1, P2, P3) and to consider their prospective performance criteria (E1, E2, E3). It may appear to be too costly (E1) to directly input to the computer an alphanumeric data item (D1) which is of high volume (V1) and even of relatively low volume (V2). But, if it is realized by management that not only the purpose of pure document reproduction (P1) but also other purposes (P2, P3) could be served thereby, leading to some significant, advantageous performance indicators (in E2 and E3), perhaps the investment in such technology can be justified after all.

3.1.3.2 Direct Data Entry

The possibilities of directly entering data (of volume V2) into the ERIC system have already been addressed by an ERIC-associated staff group and described in a final report [DET-1]. ERIC is to be commended for having undertaken such a project, although the study was unfortunately unrealistically short and encountered various problems with equipment installation, communication line errors, and personnel training and motivation. Consequently, although it constituted an experimental comparison of alternative technological modes of data entry to ERIC, the statistical validity of the collected and analyzed data must be seriously questioned (as is in fact done by the authors of the report). Nevertheless some useful indications, recommendations and conclusions can be gained from the reported work, as long as they are viewed in their proper perspective. As will be observed in the following three sections, references will be made to those results.

Due to their apparent importance to ERIC [DET-1] as well as to other noteworthy organizations, such as the U.S. Congress [DET-2], the current and prospective technological alternatives for entering data into a computer are discussed below in the following order:

1. Optical character recognition

2. On-line terminals

3. Word processing equipment

Our reasoning behind this particular ordering of the topics should become apparent in the three sections to follow. Comparisons in terms of our defined data input characteristics and criteria are made in Section 3.1.5.

3.1.3.3 Optical Character Recognition

OCR specialists cite interesting figures on reading performance by OCR equipment. Typical OCR character acceptance rates for single-font (machine printed) characters are expected to be 99% to 99.99% [OCR-1]. That same source quotes the expected acceptance rate of 97% to 99.5% for OCR direct reading of multifont (machine printed) characters from source documents generated by up to 10,000 different typewriters with up to 40 different fonts involved; the rate is between 98% and 99.5% for reading numeric handprinted characters meeting industry and manufacturer standards. However, certain albeit "remarkably few constraints" still apply when it comes to recognizing handprinting [OCR-2], although it is safe to say that the OCR technology will continue to be improved to minimize restrictions.

Yet, it would appear that current OCR data entry systems still leave something to be desired, especially from the standpoint of ERIC requirements. The previously cited data entry study [DET-1] listed several disadvantages of OCR including difficulties in making corrections and rigid requirements for character density and alignment to prevent misreads.

However, advancement in the state-of-the-art of OCR technology can surely overcome such problems and render OCR much more flexible and forgiving. What is really of greater significance to ERIC is, firstly, the fact that OCR is a very specialized piece of equipment which must be maintained by each clearinghouse but which, for the most part, is usable for only one particular operation [DET-1]. As is true for OCR in specialized transactions processing (in the banking, credit card, retailing, airlines, etc., industries) and for OCR terminal systems (e.g., with point -of-sale OCR scanners and table-top remote OCR readers), well-structured data entry applications can be quite suitably handled by OCR. But the equipment can normally not be used for anything else.

Secondly, in the currently existing processing in ERIC of the textual (surrogate) data for input via OCR, the fact also is that human operator typing is required anyhow. Whether we are discussing only the relatively low-volume (V2) surrogates or the high-volume (V1) full text documents, if microfilm technology has difficulties with legibility of the fugitive, poor-quality printing, one can easily see that accurate optical recognition of such printed characters would also be troublesome. Hence, unless the preparation of source documents can be somehow standardized or controlled, ERIC cannot expect to rely on what would be a desirable alternative [OCR-3]: the use of OCR on the source documents/abstracts directly (as outlined in Section 3.1.3.1). The labor-intensive keying of data must continue unless they are already optically readable.

If such keying is indeed required, it makes good sense to recognize the flexibility and richness in terms of data manipulation capabilities to be gained by directly keying those same data into computer-internal representation, either by means of on-line terminals or via some word processing system configuration. These options are discussed in the next two sections respectively. As will be seen, OCR will, thereby, not necessarily be replaced. Instead it can be acknowledged as one possibly useful but still specialized and restricted component in the context of a word processing system [OCR-5].

3.1.3.4 On-Line Terminals

Computer terminals range from the very "dumb" to the quite "intelligent" types. They can also be distinguished in a number of other ways: serving interactive vs. batch work, using asynchronous vs. synchronous communication, and being off-line vs. on-line. These distinctions are of course interrelated. They will be clarified in Section 3.2.3.

Many pages could be devoted to this topic alone; numerous references could be given, including surveys of available terminals [e.g., OLT-1,2,3]. But since our focus here is on direct data entry alternatives for ERIC, we only want to recognize that textual data can be keyed in using some simple typewriter-like terminal or a keyboard with an alphanumeric CRT and then be transmitted asynchronously to a computer. Thus, just as is true for OCR-keying of the same data, a human operator is required, meaning labor costs. However, that operator now has the considerable advantages of using the computer software (e.g., text editor) to aid in the data input process. Although this alternative was not recommended as a result of the previously mentioned ERIC study [DET-1], we feel that the communications problems experienced can be overcome and the cost-effectiveness of on-line entry of document surrogates is dependent on what else can be accomplished with the terminal equipment.

Rather than being a very specialized, one-operation piece of equipment (analogous to the possible criticism of OCR devices), a terminal can be considerably enhanced and rendered more or less "intelligent" through the use of microprocessors [OLT-4] and a great assortment of storage, input/output, communications and other facilities [OLT-5].

Realizing that the smarter the terminal is, the costlier it tends to be, an important question to answer deals with other ERIC functions to be served and advantages to be gained from such equipment besides the pure entry (with comparatively low error rates). As is seen in the data output section and later through the ERIC networking considerations in this report, such justifying factors are available.

In the meantime, the spectrum of possible terminal configurations which, based on how much "intelligence" is incorporated, may operate in the dependent mode (connected to a computer) and/or in the stand alone mode (doing some useful work locally, independently) leads us very naturally to consideration of what are termed "word processing systems."

3.1.3.5 Word Processing Equipment

Word processing systems can be viewed as having a history analogous to computer-oriented terminal systems: from the very simple to the quite complex and intelligent. The interesting thing is that, towards the latter (intelligent) end of the spectrum, word processing systems may be indistinguishable from intelligent computer terminals.

The ancestry of current word processing systems [WPE-1] can be sketched on the basis of office-oriented equipment starting with the lowly mechanical typewriter introduced early this century. They then moved to automatic typewriters (in the 1930's), addition of punched paper tape (in the 1950's), and then, in conjunction with the rise of computers, to the tape cartridge typing system (of the mid 1960's) which really got the current word processing started. That was succeeded (around 1970) by the magnetic card typewriters and use of magnetic tape cassettes for storage of data. The 1970's then brought a number of additional technological enhancements to bear on word processing, including video display systems, multi-keyboard systems and other data storage media such as diskettes and floppy disks.

Is a word processing system then identical to an intelligent computer-based terminal? It can be. Three different types of word processors are usually distinguished [WPE-2,3]:

1. <u>Stand-alone system:</u> Normally includes a typewriter or a keyboard with CRT, combined with edit and control logic, some internal memory and some peripheral magnetic storage device(s), such as cassette, cartridge or diskette. In addition, some more logic, arithmetic capabilities followed by software programmability can render it to be a

computer in its own right. Then, with communications interfacing provided, the word processing computer can also communicate with other similar systems.

2. Shared-logic processor: This is similar to a timeshared or key-to-disk computer system. The logic, storage capacity and peripheral devices of a central computer are shared among a number of keyboard editing stations. A minicomputer might support a dozen or more such stations. Any of the variety of other computer-controlled peripherals (including OCR input) may then become available. This shared-logic approach can be especially cost-effective in meeting high- volume textual input and editing requirements. The word processing power and capabilities sharable among a number of stations may not be affordable if a single user (or stand-alone system) is involved.

3. Timeshared service: This refers to the well-known, timesharing computer system which provides word processing support (perhaps as only one part of a repertoire of services) and can be accessed from various terminal sites. It further confirms the increasingly strong relationship between office-oriented, computer-based word processors and computer systems (or intelligent computer terminals) supporting word processing.

Numerous vendors specializing in one or more of the above-defined systems/services can be identified and compared [WPE-2]. Good sources are available to guide management in the selection and evaluation of word processing alternatives [WPE-4 through 7].

With regard to ERIC, a number of advantages of using word processing systems (which might even include selected OCR input) have already been pointed out by the authors of the data entry study [DET-1]. Other advantages can be indicated, particularly when placed into the prospective ERIC networking environment. It must be recognized, however, that there may be important implications resulting from selecting a limited-capability "word processor" as opposed to a true mini- or micro-computer based system which supports word processing. As is discussed in Section 4, subject to ERIC plans and aspirations for the future coupled with realistic determinations or projections of clearinghouse processing volumes and requirements, the computer-based approach should be seriously considered. That is also part of one of the major alternatives for ERIC suggested in Section 5.

3.1.3.6 High or Low Volume

Inherent in our discussions of microfilming and computer-based means for inputting data into ERIC has been an implied but very real "data volume gap." The technology for microfilming has largely been used and justified as suitable for high-volume full-text input (V1); the various computer-oriented means, including OCR, on-line terminals and word processing systems, have actually been primarily employed for low-volume input (V2). The distinction in ERIC is of course between full-text documents and their surrogates (or resumes).

Can computer-based word processors (which might include an OCR capability) accommodate input of the full-text, fugitive documents of interest to ERIC? Under present circumstances, no. Furthermore, it is unlikely that ERIC will or should altogether replace microfiche until or unless a number of difficulties are solved or advancements are made, including:

1. Standardization or better control over document input, resulting in more reliable (perhaps direct) use of OCR or possibly even leading to encouragement/requirement of direct document input to a computer-based medium by the authoring agency.

2. Development of ERIC interests in doing more with the contents of full-text reports and other items than only storing and reproducing them. One example would be the extraction and adaptation (editing, formatting, etc.) of selected report segments for local use (e.g., by a teacher).

3. Further advancement and maturing of the technology for providing cost-effective peripheral mass storage facilities, preferably searchable in nature.

Because of the obvious requirement of supporting large-volume data input with some alternative mass storage facilities, several selected technologies are briefly described in the next section.

3.1.3.7 Selected Storage Technologies

The computer-associated peripheral memory systems that are most prominent and best understood are the magnetic disks and drums and tapes. Quite a lot of data can of course be stored on magnetic tape, and many current systems including ERIC are doing exactly that. But their sequential, slow-access and relatively bulky nature does not really make them very attractive. Still they are being used economically for such things as surrogate data storage and dissemination (by mail).

Ordinary fixed- or moving head disk is faster, more expensive and also awkward (especially for mailing). It takes quite a bit of disk for storage of full-text documents and the use of such an efficiently searchable medium for that purpose must be questioned unless full-text searching or analysis is to be carried out. Disk-based searching of bibliographic data bases (including author, title, index terms etc.) is quite reasonable and is being done by many existing computerized information systems (offering a great variety of data bases including ERIC).

So what peripheral memory technologies have been or are being developed as possible future alternatives to microfiche? A useful report which describes and compares the variety of such systems has recently been produced by the National Bureau of Standards [ORT-1]. Separate reports have also been written to focus exclusively on one particular type of memory, e.g., magnetic bubble memory [ORT-2].

In the interest of ERIC and because of NIE references made to these particular memories, we wish to briefly characterize two of the most prominent: optical (laser beam) memory and video-disk memory. A third type, namely holographic memory [ORT-5] giving 3-D effects, is an "optical relative" appearing to be too expensive and impractical to warrant ERIC attention at this time.

The optical laser beam addressable memory is viewed as a potential alternative to conventional magnetic memory. The data are stored in track-oriented format on metalized film strips [ORT-1]. There are 13,000 user tracks per strip and 15,385 eight-bit bytes per track, giving a total formatted capacity (not including overhead) of 1.6 billion bits. A present laser memory system (compared with a moving-head disk system) has a capacity of 1 terabit (vs. 2500 megabits) with a transfer rate of 3.2 megabits (vs. 10 megabits)per sec. Average access time is less than 20 second (vs. 35 milliseconds for disk). The cost is listed at 360 microcent/bit (vs. 1 millicent/bit of disk). While the laser memory is of much greater capacity, likely to increase to as much as 1000 terabits for future library purposes, and while it is cheaper (projected to go down to 10 microcents for a 2 terabit memory and as low as 1 microcent for a 1000 terabits), it is considerably slower. The average access time may perhaps go down to 10 seconds or so. Although it displays a number of advantages (in terms of compactness, modularity, reliability, etc.), it must be viewed as a storage alternative primarily suited for maintaining (or archiving) data rather than dynamically/interactively manipulating and searching them.

Perhaps the main disadvantage of optical laser memory is that it is still in its infancy. While ERIC should acknowledge its potential future attractiveness, current reliance on or planning for its availability is not suggested. Commercial successes have not been numerous and whether or not it is economically competitive with presently existing mass memories remains questionable.

Similar statements can be made about the immaturity of videodisk systems, although they may already have gained more attention [ORT-3]. Except for some commercial optical video- disk (television) playback systems, such memories (for computer mass storage purposes) are not yet available. However, their projected characteristics are of interest. Information is stored in various forms (analog and digital) on a disk which is similar to a phonograph record. Most such disks then use optical means for writing and reading the data. Advanced laser or electron-beam techniques are used to pack the data. For a proposed commercial system with analog format, a one-micrometer, variable-length pit (or oblong hole) is used to represent the data [ORT-1]. Up to six bits can be stored in each pit. There are 32 sectors per disk and 14,498 bits represented in each sector. Thus, with 40,000 spiral tracks per side of disk, the total unformatted capacity could be 10 billion bits. In projecting to a future 1 terabit videodisk memory, it should be 10 to 20 times faster in transfer rate than the previously described 1 terabit optical laser beam memory, its average access time should be much faster (50-100 milliseconds), and its cost should be much lower (about 20 microcents/bit). Note that, given the estimates used in Section 3.1.1.2 on the size and number of reports input to the ERIC system per month, a 1 terabit memory (1000 billion bits) could contain roughly 200 months' worth of full-text data.

Videodisk systems are being considered as particularly suitable for use in future computer-controlled information storage and retrieval systems, especially for mass storage purposes. For the latter, they do appear to hold more promise than the competitive market of magnetic disk and mass tape. However, videodisk is a read-only technology while disk and tape are erasable. Again, it is considered to be premature for ERIC to plan for the definite use of videodisk, although the advantages and prospects should be recognized and kept in mind.

A better approach is to attend to a more effective blending and integrative structuring of currently available computer-based and micrographic technologies, as indicated in the next section and as further pursued later on in this report. Among the desirable consequences should be the preparation for and facilitation of future replacement of any technologically outdated component of a hybrid ERIC system.

3.1.4 Computer-Microfilm Composite

In order to overcome the sometimes "schizophrenic" separation of high-volume and low-volume data input technologies, it makes good sense to consider the complementing or combining of microfilm and computer technologies into effectively coupled systems. These could bring them into a mutually beneficial, closer harmony with resulting potential for technological cross-fertilization. The possibilities to be mentioned still adhere to the input side of ERIC, consistent with the title of this chapter, although a "second input" step or iteration may seem to be involved.

Firstly, the use of computer-output microfilm (COM) has gained increasing popularity. The data (characters) which have already been entered somehow into internal computer representation are displayed by some technological means (e.g., CRT) for purposes of direct microfilming. The worries of poor-quality source items are thereby of course eliminated. Also, the data, which must already have been input to the system, can be suitably manipulated or processed before being stored on film. That is a considerable advantage. Subsequently, you have the same data storage medium to deal with which was described in Section 3.1.2. COM should, however, produce uniformly high-quality results.

The literature includes some interesting descriptions of COM and its advantages. Examples are a comparison of COM and CRT with regard to "real-time" services [CMC-1], how COM promotes further archival applications [e.g., CMC-2] as well as possible throw-away non-archival uses [e.g., CMC-3]. Appropriate standards already exist [CMC-4].

With regard to ERIC, we are happy to report that a limited use of COM, for getting computerized surrogate resumes from the ERIC Facility directly microfilmed at EDRS, has recently been initiated. This use can be expanded and enhanced if adequately powerful computer-based word processing systems (discussed in Section 3.1.3.5) are deemed to be in the future for the ERIC Facility and the Clearinghouses.

One further kind of computer-microfilm composite applicable to data input is the use of a high-resolution flying spot scanner [e.g., CMC-5] in order to read alphanumeric data from microfilm directly into the computer. Use of this approach is as yet far from widespread and its reliability needs to be improved. Clearly, this presupposes once again that the source documents which had to be microfilmed were of adequate quality to enable reliable reading and character identification. Nevertheless, for a system as heavily dependent on microfilm as is ERIC, the direct input from selected microfiche to a computer is worthy of future consideration. It could close the loop between computers and microfilm and allow the latter to be viewed as a form of computer-compatible storage.

3.1.5 Text-Oriented Input Alternatives

As was promised at the beginning of this "Data Input and Representation" section, when pertinent characteristics and criteria were defined, a tabulated comparison of the major technological data input alternatives is to be made. Table 2 shows the results. The labelled characteristics and criteria are consistent with those displayed in Table 1.

The first six listed input alternatives have been discussed in this section. A couple of others are added for sake of completeness and are mentioned further in the next subsection.

Table 2 does not attempt to exhaustively cover all possible combinations of the D-V-P characteristics and E criteria outlined in Table 1. One reason is that, in the interest of the currently existing ERIC system and the NIE-indicated study priorities, the most prevalent alphanumeric data type (D1) with two major associated input volume levels (V1 for full text, V2 for surrogates) has been our primary focus of attention.

Secondly, the indicated (row-wise) profiles of performance for selected D-V-P combinations are necessarily only general guidelines and should be interpreted accordingly. In fact, to substantiate the suggested ratings the reader should not only peruse pertinent sections of this report but also some of the cited literature. In addition, because this study did not involve experimental collection and analysis of data, the future sponsorship of carefully planned formal comparisons of selected alternatives for possible application to ERIC is encouraged.

To aid in reading Table 2, several examples are cited. The first profile (or row) for ERIC use of microfilm says: Both high- and low-volume textual and numeric data (and partially also graphic and diagrammatic information) can be handled efficiently for purposes of storage and reproduction, except that the results may vary from good to poor depending on quality of data input. Notice that the E3 (user satisfaction) criterion is not applicable as yet until we look at the media in terms of output or presentation to users (in Section 3.2). The second profile for microfilm, on the other hand, states that all types of visual data cannot currently be serviced by microfilm for purposes of data searching, analysis or transformation. This situation could change of course if the typographic quality (and hence microfilm image quality) of input documents were such to enable automatic reading from microfiche to computerized form (see Section 3.1.4).

With the Technological Alternatives of:	Given Data Iutput of Type: D1 (1)(a)	D1 (1)(b)	D1 (2)	D1 (3)	D1 (4)	D2	D3	D4	and Data Volume: V1	V2	V3	and Data Purpose: P1	P2	P3	Resulting Performance is Relatively Good (G), Fair (F), or Poor (P), Impossible (I), or Not Applicable (-) E1(1)	E1(2)	E2	E3
Microfilm or Fiche	+ +	+ +	+ +	· +	· +	 *	 *	 *	+ - -	+ - -	· - -	* +	 *	 *	G - -	G - -	G-P I I	- - -
Optical Character Recognition	*	*	*	-	·	 *	 *	 *	· -	+ -	 -	+	+	+	G -	G -	G-F I	- -
Simple On-Line Terminals	 *	*	*			 *	 *	 *	 + -	+ -	· -	+ +	+ +	+ +	G F-P -	G-F G -	G G I	- - -
Word Processing Systems	 *	*	*			 ·	 ·	 ·	 +	+	· +	+ + +	+ + +	+ + +	G F F	G-F F F	G G F	- - -
Computer-Output Microfilm	+	+	+	·	·				+	+	·	*			G	G-F	G	-
Computer-Read Microfilm	+	+	+	·	·					+	·	+	·	·	G-F	G-F	G-F	
And Others:																		
Audio Tape Recording						*			+	+	·	+			G	G	G	-
Audiovisual Recording				*	*	*		*	+	+	·	+			G	G	G	

Legend:

- \+ Normal Applicability
- · Partial Applicability
- * Determinizing Factor
- \- Not Applicable (or Obviated)

Table 2. Selective Characterization of Technological Data Input Alternatives

OCR can be used efficiently (especially for low volume input) and effectively on textual and numeric types of data and combinations thereof, but its performance can become much less effective unless the input is clearly recognizable (i.e., fugitive documents/surrogates in ERIC cannot be expected to be read directly). Because OCR enables the actual identification and subsequent internal storage of alphanumerics, it can serve to support all three types of purpose. This is also true for simple on-line terminals and word processing systems. However, in those cases, due to various computer facilities being accessed and/or incorporated in the local system, the efficiency factor (in cost and human labor) tends to go down while the quality of the results goes up. As stated before, to really appreciate what mini- or micro-computer based systems can accomplish for ERIC, one must look beyond the simple ratings of Table 2 and consider them in the full context of potential improvements of ERIC on the whole.

Tabulations of the kind displayed in Table 2 can obviously not portray all the factors, issues and arguments which go into deciding that one technology is perhaps better than another. Therefore, the reader is encouraged to view such tables in this report as only generally highlighting selected investigative results. More importantly, in our opinion, is their usefulness in providing guidelines to management via the inherent structure or framework of factors which, although they could be much more detailed and refined, should be utilized towards comprehensively considering technology-based improvements of ERIC.

3.1.6 Non-Textual Alternatives

Analogous to the range of possibilities defined (in Section 3.1.3.1) and subsequently discussed for visual data, especially of the alphanumeric type, we could characterize available technologies with emphasis on graphic/pictorial data, or on audio data, or even on tactile data, and finally on combinations of all types. Some of these are of course much further developed than others. Regrettably the scope and length of this study precluded our doing so. However, in view of some strong interests expressed by ERIC-associated personnel in making other types of data (e.g., audiovisual) identifiable and perhaps actually available through ERIC, such detailed characterizations and comparisons may be desirable follow-ups to our work.

3.2 Data Output or Presentation

Just as an information system must have facilities for inputting or representing data internally, it must be able to output the results of data reproduction, manipulation analysis, transformation or searching for suitable presentation to the intended users. The various technological alternatives already described in terms of input capabilities must now lead to and be scrutinized from the standpoint of interfacing or interaction with people.

3.2.1 Output Characteristics and Criteria

Once the data have been input or copied into a particular storage medium, and after perhaps being variously processed therein depending on the power and capabilities of the system involved, we must ask how the available technology can serve to get user-desired data (or information) out of the system in a form or on a medium that is amenable to satisfactory human use. Analogous to what we did for input data, we must therefore define data output again with regard to distinguishing characteristics and appropriate criteria for general assessment of performance.

3.2.1.1 Data Types

Since visual as well as possibly audio and even tactile data (and combinations thereof) are of interest to people on system input, it stands to reason that the same types of data are to be output. The data themselves may have been repackaged or modified, but their typology remains the same Without full repetition, we can therefore again use the definitions (of D1, D2, D3, and D4) made in Section 3.1.1.1 and outlined in Table 1.

3.2.1.2 Output Quantities

The volume levels of data output should however be treated somewhat differently than those on input. If we are interested in user-oriented technology application to ERIC and similar systems, we must design to meet the data volume levels which are likely to be wanted or which can be assimilated by the data users. This means that even if the full text of a report had been input to the system, the user may only wish to see one line, one paragraph, one page, the bibliographic citation, or some data unit resulting from a search, an analysis or a transformation of the text. Finally, the user may actually want to see and read the whole document.

Given this kind of quantitative view of what ERIC users might want to get our of the system, where our emphasis is again on visual data, the following categorization is reasonable:

Q1. Single- or Multi-Line Quantity (up to a Paragraph)

Q2. Single- or Multi-Paragraph Quantity (up to a Page)

Q3. Single-Page Quantity (including Graphs, Diagrams)

Q4. Multi-Page Quantity (up to and including Full Text)

3.2.1.3 User Purposes

On the input side, we asked about the purposes of the data once they had been read into some technological storage medium, possibly in conjunction with some data processing capabilities. Those purposes were obviously defined in anticipation of what the users might want to do with the data on the output side. Notice that the user purpose can be separated out from the user- desired output quantity (previous section) although those two characteristics may be very much related.

Starting in the 1960's and moving through the 1970's, gradually but significantly increasing attention has been paid by information and computer scientists to user needs and preferences in relation to information systems. The pertinent literature is too large to be adequately treated here. Some user-oriented evaluation studies are included in the EVA category of the bibliography. Other samples are listed in the USI category, representative of user-oriented work conducted under the sponsorship of ASIS (e.g., USI-1 and 2), ACM (e.g., USI-3) and NBS (e.g., USI-4 and 5). These studies primarily focussed on user interaction with computer-based information systems. But user-oriented concerns about interfacing with other technologies are also evident in the literature (see MFF category).

So what kinds of purposes may users have in mind in attempting to take advantage of an information system like ERIC? Towards the end of characterizing the technological alternatives in this report, they can be categorized as follows (without implying any judgement on the relative merits):

U1. Obtaining Verbatim Copy of Data Unit

(1) Entire Unit (full text, surrogate, graph)

(2) Subset or Extract of Unit

U2. Obtaining Selected Search/Analysis Results

U3. Obtaining Transformed/Modified Image of (Sub)Unit

U4. Getting a Cursory View of Data (Browsing)

It must be noted that we are not making distinctions here between end and intermediary users (or information specialists), between regular and occasional users, between experienced and novice users, and with regard to other possible taxonomies. In detailed system design, such distinctions should be taken into account. For purposes of

Table 3. Characteristics and Criteria for Investigating Data Output Technology

DATA OUTPUT CHARACTERISTICS:	Label
Type of Data	
Visual Data	D1
Textual or Alphanumeric	D1(1)
Full Text	D1(1)(a)
Surrogate	D1(1)(b)
Statistical or Numeric	D1(2)
Graphic, Diagrammatic, Pictorial	D1(3)
Combination of above	D1(4)
Audio Data	D2
Tactile Data	D3
Combinations of above	D4
Output Quantity	
Single- or Multi-Line (up to Paragraph)	Q1
Single- or Multi-Paragraph (up to Page)	Q2
Single Page (or Graph, Diagram, Picture)	Q3
Multi-Page (up to/including Full Text)	Q4
User Purpose	
Obtaining Verbatim Copy of Data Unit	U1
Entire Unit (Full Text, Surrogate, Graph)	U1(1)
Subset or Extract of Unit	U1(2)
Obtaining Selected Search/Analysis Results	U2
Obtaining Transformed/Modified (Sub)Unit	U3
Getting Cursory View of Data (Browsing)	U4
OUTPUT PERFORMANCE CRITERIA	
Efficiency	E1
I/O Processing Rate	E1(1)
I/O Processing Cost	E1(2)
Effectiveness	E2
Quality of Output (w.r.t. Purpose)	
Synergism	E3
User Satisfaction	

this study, however, all of the above can be considered as applicable to all types of direct users, although to differing extents.

3.2.1.4 Performance Criteria

To assess prospective performance levels for various technological output alternatives, it is again possible for us to use the same criteria employed on the input side. These were defined to be efficiency (E1), effectiveness (E2) and synergism (E3) criteria, as discussed in Section 3.1.1.4 and outlined in Table 1.

Although a thorough, formal system evaluation would require treatment of a number of additional questions pertaining to each of the three general criteria, our study scope limits us to the selected few. Also, a marked change of emphasis, from data input to data output, should be noted: While synergism (E3) was practically ignored on the input side (see right-most column of Table 2), it should become very prominent in user-oriented consideration of output technology.

3.2.1.5 Framework of Factors

With much more brevity, we can now summarize the characteristics and criteria to be referenced in the following discussions of technological alternatives for providing user-oriented output from ERIC and similar systems. This is analogous to what was done in Section 3.1.1.5. Table 3 should be self-explanatory.

3.2.2 Microfilm and Fiche

ERIC does not only use micrographics for purposes of "archival" storage, which may connote to the uninformed person a relatively nonuser-oriented, dusty-shelf storage of information for historical interest. In fact, the interest is in both current awareness and retroactive uses of high-quality, clean microfiche by the many people in the educational community. So what are the types of uses of microfilm, and what do users seem to think about it as an output medium?

3.2.2.1 Dependence on Input

Unlike information systems in which the data, upon input, can be flexibly modified and even corrected or improved, the very nature of microfilm is that the quality of the output is directly and intimately dependent on the quality of the input (document and/or filming process). It should be pointed out that some selective modification/correction of microfiche contents is technologically possible but unlikely to be useful for overcoming the general problems with fugitive documents in the ERIC system.

3.2.2.2 Range of Uses

Once a microfilm image of some input data has been produced, regardless of whether the microfiche is brand new or selected from previous storage, what are users able to do with it? We can relate this question to the user purposes identified in Table 3 as follows:

1. The user can read the entire contents or a selected part of the microfiche (U1).

2. The user can simply browse through all or part of it (U4).

3. The user can get a paper copy of all or some of the pages on the fiche (again U1).

4. The user can have the microfilm itself reproduced (also interpreted under purpose U1).

   In addition, when a single microfiche is viewed as part of a physical collection of microfiche (not an indexed, computerized surrogate file),

5. The user may be able to access a physical ordered and/or controlled microfiche collection based on a limited search capability to identify (e.g., specifically numbered) fiche (under U2).

The search is "limited" in that detailed character- or word-oriented analyses (U2) as well as data transformations (U3) are not possible using microfiche (unless and until input documents and image quality enable direct reading of the textual data from microfiche to computer storage).

The next several subsections discuss the above-indicated uses of microfiche in more depth. Some of the ERIC-related problems with technological output devices and some ERIC staff opinions about them are thereby shared.

3.2.2.3 Reading and Browsing

The reading or browsing through a visual information medium can be an intensely important and exciting human activity. This should be supported and enhanced with user-oriented technology including, in the ERIC case, properly formatted microfiche (or other kinds of microforms) with pages arranged for natural and convenient user operation. But we shall not dwell on such fine-tuning here. Our priority concern with microfilm-based output is reader quality in general.

Even if EDRS has the most beautiful, state-of-the-art microfilming technology installed and properly utilized, and assuming that an input document is of high typographic quality, ERIC users will not be satisfactorily served if the microfilm reading devices available in information centers or user organizations are of inadequate quality. Secondly, if those devices should be good enough but the users are untrained, uninformed or even unwilling to use them effectively, microfiche reading and browsing can also be a frustrating, disillusioning experience. And who tends to get blamed? Central ERIC, or EDRS, or microfilm technology in general.

Again, as has been stated before, the technology is or surely can be good enough. In spite of the good intentions of those advocating inexpensive microfilm readers, use of better quality (and probably more costly) readers should be encouraged and promoted. We know both how to design and develop better readers as well as how to evaluate and select them [MFF-20 and 21]. Several persons associated with ERIC have told us: The problem is that the educational (and associated scholarly) communities are relative paupers, compared with other segments of society. Hence, the equipment manufacturers find them comparatively unattractive (financially) as a market. This combination of factors contributes to the availability and excessive use of "cheapy" readers which tend to counteract sincere efforts made by ERIC on other parts of the system.

Secondly, the users must of course not only be motivated to use ERIC microfiche but also be trained in its use. Some people told us that the "hold-the-fiche-before-the-window" syndrome still exists, very unfortunately. While that may sound exaggerated, it is true that, especially for those in the education community who may not be technology-oriented or who even have an aversion to it, lack of training in the use of microfiche readers (compounded by inexpensive, low-quality readers) will certainly not advance the objectives of ERIC or enhance its reputation.

An ironic byproduct of the above is that many users, who are actually conditioned to very poor microfilm readers and reading habits, don't know that things could be significantly better. They may, therefore, be inappropriately counted as so-called satisfied users or, alternatively, be "turned off" to microfiche use after a succession of unhappy experiences.

3.2.2.4 Paper Copy Production

ERIC users who want to get a paper copy of a report produced from microfiche can do so by either ordering it from EDRS or by employing miscellaneous local equipment (e.g., microfiche reader/printers) if available. The latter alternative is generally not very satisfactory, largely for reasons similar to above-mentioned low-quality equipment for reading. But it is considered better than nothing when a selected paper copy is needed.

The former alternative (ordering from EDRS) is likely to take more time but will normally produce better results. The various problems with microfiche production, already discussed in conjunction with data input (Section 3.1.2), naturally come into play. They will not be repeated here. It should be noted, however, that we found general satisfaction expressed on our ERIC-associated site visits as far as paper copy service from EDRS is concerned. This is particularly true for more recently entered documents and in spite of the fact that in a high-volume production shop individualized attention to problem pages is difficult to achieve. Those cases which involve complaints and/or requests for better copy generally seem to be handled responsively by EDRS.

The above is not to suggest that paper copy production from microfilm results in uniformly good results. Poor-quality fugitive documents remain a fact of life in the current ERIC system. The Reproducibility Guidelines discussed in Section 3.1.2.8 are necessary, although some people feel they are too restrictive. In addition, what may be worst as far as present paper copy users are concerned is the uncertainty as to why a copy is almost illegible or inexplicably tiny in print. Explicit, individualized identification of the source of such problems (which EDRS now records in a daily diary) would go a long way towards alleviating user complaints. Current, more general disclaimers [see MFF-12] seen by users are interpreted by some people as routine cover-ups.

3.2.2.5 Duplication of Fiche

Users of microfiche may also want to have duplicates of microfiche made, for very selective purposes or for developing separate subcollections of fiche. The main technology-related problem associated with such duplication involves the further deterioration of image quality in going from one microfiche generation to another. This is substantially dependent on what kind of film master is used. Silver is better than vesicular for duplication purposes. EDRS uses silver [MFF-10], but only a small set of subscribing customers order and receive silver microfiche. All others get the vesicular. The latter may be quite adequate, especially if the vesicular is not used for further microfiche duplication [MFF-12]. Silver may or may not be the right choice for customers, depending upon how carefully and for what purpose they use it. To copy (i.e., duplicate) microfiche it may be desirable. However, for that case the diazo alternative might also be considered.

In any case, the users should be properly informed and then have the choice (assuming they are willing to pay for it). The sensitivity of certain users to this issue was evidenced in a false alarm editorial notice [MFF-22] which claimed that ERIC was henceforth only going to provide vesicular masters. In view of previously indicated problems with duplicating from vesicular, the writer projected the highly regrettable expectation of having to "make do with diazo duplicates made from earlier generation vesicular masters" when the last one that had been supplied "had about as much contrast as a grey cat on a foggy night." That's a rather strong quote and hopefully was overstated (and led to a satisfactory resolution). But, upon checking on the claim about loss of the silver option, we were assured by ERIC that it is absolutely false [see also MFF-12].

3.2.2.6 Searching a Fiche Collection

Most microfiche collections are stored and searched manually. But, by means of various types of color codings, compact shelvings, tub files and other special physical/logical arrangements, more semi-automatic mechanical and electronic filing systems are being implemented. Such aids (e.g., with selectively lighted, subject categorized boxes) can also be used for semi-manual compilation and distribution of microfiche based on standing user profiles of interest.

As microforms become more closely coupled with computerized information systems, chances are that their search will become increasingly computer-controlled and consequently more automated. This prospect will be reiterated later (in Section 3.2.4).

3.2.2.7 Future Prospects

The one prospect just mentioned above, namely greater automation of microfiche collections , is very likely to influence and also enhance the micrographic-based, user-oriented output of the future. This is consistent with what we stated about future micrographic storage in Section 3.1.2.10. Color fiche is already available and is nice to have from the user's standpoint. While it is likely to become more prominent, it will probably remain unnecessary for ERIC, until or unless ERIC inputs more special graphic/pictorial data in color. In addition, it is likely that a greater variety of microforms (including ultrafiche) will be designed and employed, both in the interests of computer-associated efficiency and of user-oriented effectiveness and synergism.

3.2.3 Computer-Based Means

The computer-based alternatives (to microfiche) which may be available to ERIC users for getting information out of ERIC, whether directly or through some intermediary information specialists, require a brief look at the typical distinctions made. These depend heavily on the output characteristics previously defined and listed in Table 3.

3.2.3.1 On-Line vs. Off-Line

The term "on-line" is usually employed to refer to an interactive, quick-response connection between a user and a computer and also between a computer terminal (perhaps "intelligent") and a computer. The object computer in question is normally being thought of as timeshared or multiprogrammed. Hence a user or local (smaller) computer or terminal communicating with it is imposing demands which may cause deterioration of the services experienced by other simultaneous users (whether human or otherwise). Nevertheless, on-line searching (e.g., of ERIC databases) has been found to be steadily gaining in popularity [EVA-3].

"Off-line," on the other hand, connotes doing your own thing locally, using perhaps a special mini- or microbased system, without bothering some other resource computer which may be located at an organizationally centralized site. That does, however, not preclude the possibility of going on-line when and if necessary, assuming the communication facilities exists.

3.2.3.2 Interactive vs. Batch

Another distinction involves a human user working in the interactive, fast-response mode with a computer, as opposed to the batch mode. The latter is typically associated with a batch of punched cards (maybe consisting of user jobs) being read en masse into a card reader, with processing results to be output on a printer at possibly variable (non-interactive) intervals of time. A hybrid combination of the two modes is also possible (e.g, interactive request and batch output).

Notice that a user can "interact" with a remotely located resource computer as well as a relatively limited local standalone system, such as a word processor. The user may be on-line to a smaller system while that same system may be either off-line or on-line relative to some other computer it can be connected to. This will have a bearing on our networking and distributed processing considerations later on.

At this point of the report, we are interested in characterizing data output with regard to usage modes. Hence, as far as output quantity is concerned (see Table 3), users are unlikely to want or be allowed to read much more (for purposes U1, U2, and U3) than relatively low-volume output (Q1, Q2, Q3) while they are in the interactive mode. Perhaps if they have a suitable output medium (see next section), they could quickly browse (U4) through a longer text (Q4). However, if they are on-line with an interactive terminal to a multi-user system, and if they want a printed copy of a document, they are usually asked to request a batch-oriented, high-speed printout. This further confirms the previously mentioned data volume gap. The next two sections describe the available technological output and storage devices used to accommodate the different volumes for different purposes.

3.2.3.3 Hard vs. Soft Copy

Interactive terminals basically come in two types: the hard-copy (or paper-copy) terminal [OLT-2] producing printed output and the soft-copy terminal producing visual (CRT [OLT-3] or plasma [OLT-6]) display. The asynchronously communicating hard-copy terminals are usually like typewriters and their printout rate is slow. The soft-copy variety (with associated keyboard and perhaps other special input devices) may range from slow to rather fast output, depending on whether it is strictly alphanumeric or fully graphic or something in between. The latter is of course subject to how much intelligence, including synchronous communication capability, might be built in.

Batch terminals are hard-copy devices normally associated with high-speed printers. Other facilities can be added and they may in fact be components of local computer systems. Considerable emphasis is placed on providing acceptably high-speed, synchronous communication lines.

An on-line searcher (with purpose U2) of the ERIC data base, accessing one of the commercially available systems [e.g., USI-7] is, therefore, likely to get brief responses (Q1 and Q2) and reasonably short lists of bibliographic citations (Q3 and Q4) printed on a hard-copy or displayed on a soft-copy, interactive terminal. For the latter, equipment also exists to get the current "soft" page (alphanumeric/graphic) reproduced in hard-copy. However, a printout of more extensive length (e.g., the responsive abstracts) should be obtained via some (hard copy) batch terminal. Among the print technologies which are particularly prominent in current word processing systems are the inkjet, the laser, and the magnetic high-speed printers.

3.2.3.4 Peripheral Storage

But what if the user does not wish to visually read or browse through the data right now (on either hard-copy or soft-copy terminal)? What if the data are to be somehow obtained, from a remote or local source, and stored on a computer-compatible medium for later search/analysis (U2) or transformation (U3) or something else?

In this context, it is reasonable to consider various types of peripheral storage as user-desired alternatives (to above-described hard- or soft-copy) for data output from information systems. We are again led to inquire about low- and high-capacity peripheral memories, as we did in Section 3.1.3.7. But now our focus is necessarily on the relatively low-capacity storage.

Besides having the conventional disk and tape, the development of intelligent terminals and word processing systems has brought with it a number of attractive peripheral storage devices. These include cassettes, cartridges and various diskettes. Of special interest to prospective use of word processing systems in the ERIC network is the availability of floppy disks.

Floppy disk is the relatively low-capacity, low-cost answer to block-random-access storage for small computer systems [ORT-1]. It is like a large, circular piece of magnetic tape coated with oxide mylar. Particularly suitable applications include data entry systems, intelligent terminals and remote batch terminals, as discussed above. A typical single-density floppy disk has an unformatted capacity of 3.2 megabits, a transfer rate of .25 megabits/sec., an access time of about 200 milliseconds and a price of 19 millicent per bit. The floppy is easily filed and accessed but must be carefully handled. It has some remaining disadvantages (like magnetic tape), including difficulties with incompatibility, or lack of standards, among different manufacturers. The National Bureau of Standards is taking initiatives to address that problem.

3.2.3.5 Remote vs. Local Search

Local accessibility has been consistently found to be one of the most user-desired features in information systems [EVA-3]. Among the conventional alternatives, the local library and its volumes of RIE and CIJE and other hard-copy products have been and remain locally accessible; the same can be said about an in-house ERIC microfiche collection. But many people in the educational community presently do not have such libraries and resources in their immediate vicinity.

The current design of the ERIC system, with its two major technology-based alternatives to getting information from the ERIC data bases, has generally promoted a local manual search leading to microfiche and paper copy) and a remote search for bibliographic citations. Both of these searches may actually be done by intermediaries in regional information centers, thereby removing the end user from personal, local accessibility as such. As is well known, there are differences of opinion on whether that is good or bad.

Assuming that we interpret the end user's strong preference for local accessibility to be independent of whether he/she does the searching personally or through a (locally available) intermediate specialist, then we must ask what options ERIC has to satisfy that user preference. Given the tremendous advancements in computer/communications networking, "local accessibility" to one or more complete ERIC data bases obviously is already being provided to large numbers of users. That is true even though the computer systems involved are remotely located, perhaps at the other end of the country. So, to be locally accessible does not necessarily rule out remote searching via a local terminal. What may rule it out, however, for many present and potential ERIC users is the cost of doing on-line searching of remotely located systems, especially during hours convenient to the users.

One possible alternative to consider, therefore, is the use of minicomputer-based systems with floppy disks in reasonably local information centers for purposes of local searching of at least selected segments of the ERIC surrogate database. An "all-inclusive" system could be searched periodically or on request, according to the general interest profile of each local user organization or group, and the resulting file segment/partition could be transmitted or delivered (preferably via inexpensive, night-time communication facilities) to each local mini-center for subsequent floppy disk-based searching.

The above suggestion of a type of distributed data base application in ERIC is of course contingent on the ability to segment or partition the files in an effective manner. Some ERIC-associated people told us that it definitely can be done; others claimed that it is impossible because ERIC users always want access to the entire database. According to Havelock [EVA-3] no reasonable approach to partitioning has as yet been found. But if we can find such an approach (and we tend to think that it should be possible), the computer/communications technology is clearly available to support it.

3.2.4 Computer-Micrographics Composite

Some people have viewed the availability of on-line terminals for interactive searching as posing a distinct challenge to micrographics. An interesting comparison of the pros and cons of both has been published [CMC-6]. Others have decided, on the other hand, to come up with a suitable combination or integration of the two technologies involved [CMC-7, 8, 9].

As already suggested in Section 3.1.4 for data input, ERIC's consideration of a more effective coupling of computers and micrographics is to be encouraged. This now not only means computer-output microfilm (COM) but also the possibility of combining a localized computer search capability (previous section) with computer-controlled retrieval from a microfiche collection (Section 3.2.2.6). To enhance the user-oriented search/display interface even further, an integration of the use of a CRT-based terminal for on-line searching and the use of that same video terminal for microfiche image display is also possible.

3.2.5 Text-Oriented Output Alternatives

Analogous to what was done for text-oriented input in Section 3.1.5, the alternatives for output can now be high-lighted and broadly compared in tabular form. Table 4 displays the results.

Again, the table must be properly qualified. Depending on the backup details, found in this report and in the general literature, there is certainly room for disagreement on the particular performance indicators. The first six "output" alternatives were discussed previously. In each case, there are one or more characteristic profiles pointed out. For example, microfiche used for visual data output (of all kinds, D1) to users, may be cost-effective (E1(2)) for purposes of looking at exact copies of the entire data unit (U1), even though it may take time to get at it (E1(1)) and whether or not the user will be happy with the output quality (E2, E3) is questionable. On the other hand, microfiche cannot be used for getting selective subsets of the data (other than full pages) and it may or may not be effective for purposes of browsing.

Both hard- and soft-copy terminals are shown to be good for small-quantity output, including output of computerized search/analysis results (U2), although they may be relatively costly. Large-volume printouts (Q4), however, are better left for higher-speed, batch printers. Peripheral storage devices (e.g., floppy disks) are seen as suitable for intermediate output/storage of most kinds of visual data, as long as the quantity (Q4) is not overwhelming. Subsequently, it may of course be possible for the user to access those same stored data from a hard- or soft-copy terminal.

3.2.6 Non-Textual Alternatives

More alternatives, e.g., full graphics terminals, can be easily added to Table 4 for consideration, subject to ERIC interests in expanding its emphasis on visual, non-textual data. The audio and audiovisual entries are included for sake of completeness. They are to remind the reader of the broader perspective (especially in education)

With the Technological Alternatives of:	Given Data Output of Type: D1 (1)(a)	D1 (1)(b)	D1 (2)	D1 (3)	D1 (4)	D2	D3	D4	and Output Quantity: Q1	Q2	Q3	Q4		and User Purpose: U1 (1)	U1 (2)	U2	U3	U4	Resulting Performance is Relatively Good (G), Fair (F), or Poor (P), Impossible (I) or Not Applicable (-) E1(1)	E1(2)	E2	E3	
Microfilm or Fiche	+	+	+	+	+						+	+		*					G-P	G	G-P	G-P	
	+	+	+	.	.				+	+				*	*				-	-	I	-	
	+	+	+	+	+				+	+	+	+				*	*		-	-	I	-	
	+	+	+	+	+							+						*	G	G	F	G-P	
						*	*	*	-	-	-	-		+					-	-	I	-	
On-Line Hard Copy	+	+	+	.	.				+	+	+			+	+	+	+	+	G	G-F	G	G	
	+	+	+	.	.							+		+				+	F-P	F-P	F-P	F-P	
						*	*	*	-	-	-	-		+					-	-	I	-	
On-Line Soft Copy (Alphanumeric)	+	+	+						+	+	+	.		+	+	+	+		G	G-F	G	G	
	+	+	+									+						+	G	G-F	G	G	
						*	*	*	-	-	-	-		+					-	-	I	-	
Batch Printer	+	+	+								+	+		+	+	+	+		G	G-F	G	G-F	
Peripheral Storage (e.g.,Floppy)	+	+	+	.	.				+	+	+	+		+	+	+	+	+	G	G-F	G	G-F	
						.	.	.				+		+	.				F	F	F	-	
Computer-Output Microfilm	+	+	+	.							+	-		*					G	G-F	G	G-F	
And Others:																							
Audio Speakers System						*			+	+	+	+		+					G	G	G	G-F	
Audiovisual Sound/Display				*	*	*			+	+	+	+		+					G	G	G	G-F	

Table 4 Selective Characterization of Technological Data Output Alternatives

NOTE: See Table 2 for Legend

which should precipitate ever increasing attention to the powerful, multisensory information processing capabilities of human beings.

4. TOTAL SYSTEM-ORIENTED CONSIDERATIONS

After having considered the top-priority technological components of ERIC, we must now attempt to put the pieces together in the context of a total, unified system. In Section 3.1, the function of data input or representation was addressed with respect to alternative technological implementations but without regard to how any one such functional site or node (in the ERIC "network") may relate to either similar or different functional activities carried out elsewhere in ERIC. Likewise, in Section 3.2, the function of data output or presentation was discussed. Again, aside from certain dependencies on the input media, little was said about how the various instantiations of the data output/presentation function relate to each other and to other parts or functions of ERIC.

Our ultimate objective should of course be the technology-facilitated service to current and potential ERIC users in the educational community. By the geographically distributed nature of the latter, this means "reaching out" to where the users are. Given the state-of-the-art of computer/communications technology, coupled with the Havelock-cited indication [EVA-3] of user-desired "local accessibility," the above-stated objective can be interpreted to require: networking (via communications technology) of the various present/prospective technological components of ERIC for purposes of enabling selected kinds of distributed processing in and distributed access to what could then be correctly called an ERIC network.

This section is to give an overview of what is involved in networking and distributed processing. It also identifies the resultant advantages to be gained, in terms of both user interaction with such an ERIC network as well as associated interstaff communication and collaboration.

4.1 Interconnection of Components

Why interconnect the technological and functional components of a large information system with telecommunications facilities? Are the mail service and the occasional personal telephone conversations together with selected on-line sessions with a remotely located computerized search system not adequate to connect the parts of the nationwide information service and to support the needs of its staff and users?

The answer must depend on what ERIC wants to accomplish with the system and how well it is to perform, especially to be attractive to users. A brief analogy (although only partly applicable to ERIC) can be drawn with two different networks that have been attempted under the auspices of EDUCOM. Both were to enable nationwide sharing of computer-based resources. The first, implemented in the late 1960's, was called the Educational Information Network (EIN). It was based on a catalogue of available sharable software and transmittal of computer programs through the U.S. mails, after appropriate telephone-based inquiry and coordination. EIN failed dismally. Users were not attracted to it [CAN-1]. Lack of easy, direct accessibility to the available resources was probably a major factor.

In marked contrast, the more recent EDUNET effort [CAN-2], which provides for the sharing of computer-based resources through direct user access via various communication networks, appears to be gaining in popularity and viability.

4.1.1 Characteristics and Criteria

The theme of this entire system-oriented section is communication or, more specifically, telecommunication between the components of a large information system. But, as is seen below, that does not only mean the interconnection of technological parts such as computers and computer terminals. It also can mean the more effective, logical interlinking of operational staff/management personnel associated with the "interconnected system" as well as the enhanced interaction of the users with that system.

Before addressing the concepts and techniques of "networking" and "distributed processing" in the next two subsections, we should again ask two types of questions, analogous to what we did for the component-oriented considerations of data input and output:

1. What are the characteristics of the required or desired "interconnectedness" of the information system of interest, which should have a determining influence on the technological networking and distributed processing alternatives to be suggested?

2. What are the criteria for deciding on performance of those technological alternatives?

This total system-oriented characterization now becomes considerably more complex than for any selected system component. Nevertheless it can be carried out in an analogous manner with results being similar at least in topical structure to those portrayed in Tables 1 and 3. Because this area was not indicated by NIE to be of high priority interest in our particular study, we shall only sketch the relevant items.

Firstly, the type of data to be communicated between or among component parts must be identified. As was true earlier in this report, the transmission of alphanumeric, "visual" data represents the most prevalent need in the current ERIC system. Given that fact, we must again inquire about data volume or quantity, that is, how much data is to be transmitted from one part of ERIC to another. Do the data involve short, perhaps sporadic messages (e.g. for interactive computer use) or large, bulk transmission (e.g. in file transfer) or some combination thereof? Maybe even facsimile transmission (discussed in Section 4.1.2) should be possible. Data volume requirements for any given link between two ERIC nodes (e.g. two clearinghouses) will of course influence the capacity of the required communication line. This determination is confounded further when that same link is included in a "structure" of interconnections (to be described in the networking section below) which provides for shared use by some or all other nodes in ERIC. Thus the decision on what level of data transmission capacity (or corresponding bit transfer rate) is needed on any link must be based on and justified by the collective needs of all components of the ERIC system.

Thirdly, besides data type and data transmission volume, we must again characterize the purposes of the data communications (and hence the interconnection of ERIC components by telecommunications facilities). This can be done by stratifying people interacting with the technology into at least three categories: ERIC users, ERIC supporting staff and ERIC management.

The information-seeking purposes of users remain as previously described with regard to any particular output device (see Table 3). However, to emphasize the potential advantages of interconnection, the list might be supplemented with such facilitating purposes as "getting on-line help or direction," e.g. from an ERIC staff member. The purposes of the staff members, on the other hand, must include the execution of established functional activities (e.g. input and transmission of document surrogates to the ERIC Facility), specialized local processing, maintenance of appropriate statistics, communication of policy and procedural changes to other ERIC nodes, operational collaboration among nodes, assistance to users and responsiveness to management. Finally, high-level management concerns not only subsume the user and staff purposes but also regard the all-encompassing question of whether the benefits (to users and also staff) of ERIC interconnection are worth the potential cost.

The latter leads us also to consider total systems-oriented performance criteria. Again we can do this with respect to efficiency, effectiveness and synergism factors. Depending on whether a user, a staff member or a manager is looking at ERIC performance, the interpretation of (or specific emphasis in) the efficiency-effectiveness-synergism profile is different. Top priority for management (in general) tends to be efficiency, i.e. how much is being done at what cost? Some of the important features pertaining to staff and users are discussed in Sections 4.2 and 4.3 respectively.

4.1.2 Networking

Having loosely talked about interconnecting ERIC components, we can formalize it somewhat by discussing, in summary form, the need to carry out networking. "Networking" is variously defined to be the art or, if more rigorously intended, the process of interconnecting or interfacing a set of component systems and devices, especially computers and communications facilities, for purposes of more effective accomplishment of some information-dependent application(s). The result, namely a computer communications network, then becomes the composite of the different technological parts [CAN-3], with the data (or bits) flowing over the installed communication lines possibly using a number of different media [CAN-4].

Networking technology, which subsumes communications technology, is too extensive and complex to be described in detail in this report. Only the major features with possible relevance to ERIC deliberations are highlighted. A 1976 structured bibliography [CAN-5] is available to guide the interested reader into the sizable, ever-increasing body of networking literature. A series of useful, specialized reports has also been produced by the National Bureau of Standards [e.g. CAN-6, 7 and 8]. In addition, various networking conferences and symposia [e.g. CAN-9] are sponsored every year to keep the public informed of the state-of-the-art.

As far as applicability of networking technology to ERIC is concerned, a broad approach to answering the question of whether and in what general form a true telecommunications-based ERIC network should be considered is to discuss the following scenario of "screening" steps:

1. On <u>national-level</u> network <u>communication</u>: What data transmission volumes characterize current relationships or interactions between ERIC nodes on a pairwise basis (e.g. clearinghouse to ERIC Facility or clearinghouse to clearinghouse)? What might be the projections on future data flow over those same links if the higher-volume more user- and staff-oriented technology-based capabilities discussed in this report should be made available in ERIC?

2. On <u>regional-level</u> network <u>communication</u>: To emphasize the major concern of ERIC, namely the enabling of localized or regionalized access to ERIC resources by groups of users in various remote educational communities, the same question (as in 1. above) is asked but at a hierarchically lower level. The users here might have a simple terminal in the local school library or, if more fortunate, a mini-based word processor with floppy disk, and they might regard the nearest clearinghouse or regional information center as the networking hub to tie into (if that's possible).

3. On network <u>structure</u>: If the current and projected data flow volumes should be adequately high, justifying the possible use of one or more of the available offerings in terms of communications capacity (or bandwidth), then the configuration of the interconnections between the ERIC nodes, or the ERIC network structure, has to be carefully selected.

4. On network <u>control</u>: In addition to various kinds of control (e.g. of data flow and communication errors) dependent on available technological implementation, management-level control must also be instituted in (or superimposed on) the ERIC network. The operational mechanism(s) for such control would have to be properly blended into the network structure mentioned above.

5. On networking <u>philosophy</u>: Beyond the above, it is desirable to find a management philosophy which perceives and wishes to facilitate the existing dependencies among ERIC nodes and which, therefore, is favorably inclined towards reaping the potential benefits of networking. Needless to say, reasonable justification in terms of adequately high volumes of current or projected data transfer between nodes should be prerequisite. But there may be cost trade-offs depending on the type of communication line or service procured.

The above scenario of five screening steps should be elaborated on a little further. The first two essentially ask whether the current/ projected data flow levels in ERIC are adequate to justify telecommunications- based networking. Given reliable estimates of anticipated data flow volumes, one could then review the considerable assortment of communication techniques and services and select those most suitable and cost-effective. The range of possibilities includes establishing ordinary point-to-point dial-up lines between various ERIC nodes (clearinghouses, information centers, user organizations); or higher-quality conditioned leased voice-grade lines (especially among clearinghouses, the ERIC Facility, EDRS etc.) with the possibility of sharing those lines (e.g. via multiplexing); or interconnections via one of the available value-added networks or VANs (see CAN-6); or various combinations of the above depending on ERIC operational requirements, traffic patterns and of course associated cost.

Assuming that an objective study producing careful projections on future ERIC activities and missions in the educational community would lead to adequate justification for networking (and we feel that it would), then the next step would be to optimize the "structure" of the network vis a vis performance and cost of available communication services (mentioned above), desired user- and staff-oriented services and also necessary management considerations including operational control. The last of these points us to screening step 4 outlined above. As far as the network structure is concerned, the ERIC network could take on several possible alternatives:

1. Physically Centralized: Each of the 16 clearinghouses could have a communication link to the selected central computer site, perhaps the ERIC Facility (or its computer service contractor). Unfortunately the ERIC Facility (located in Bethesda, Maryland) is not situated very centrally with respect to the U.S. geography. Hence, if dial-up or leased voice-grade lines were to be employed, they could be quite costly. However, some line-sharing techniques might be applicable for any cluster of clearinghouses located in the same vicinity.

2. Physically Decentralized: Each of the clearinghouses and perhaps other information centers, as well as the ERIC Facility and EDRS, could be viewed as relatively autonomous information processing sites which can be interconnected in a pairwise manner (using voice-grade lines) subject to traffic patterns and needs. The overall decentralized structure can therefore take on different forms, ranging from minimal to maximal connectedness. Each major node could have its own local or regional network reaching out to hierarchically lower-level user organizations (e.g. schools, libraries etc.).

3. Logically Centralized or Decentralized: Because of the nature of information processing and routing in ERIC, some of the interdependency naturally calls for a centralized structure (e.g. all clearinghouses submitting surrogates to the ERIC Facility) while some of it calls for decentralized communication (e.g. collaboration among sets of

clearinghouses). It would appear then that networking in ERIC should provide the best of both worlds. Technologically this is quite possible by employing communications facilities (or a communications subnetwork) which is distributed in nature such that the nodes tied into it can view it as logically centralized or decentralized or both, regardless of the physical arrangement of the links.

This discussion has thus far presumed the feasibility of "total" ERIC networking. If that were to become true, based on support from the all-important management philosophy (screening step 5 above), then NIE/ERIC would be faced with either designing and implementing its own network, contracting out to have a competent organization do it for them, or tying its major processing nodes into one of the available communications networks (e.g. VANs). The last of these alternatives is becoming increasingly popular and viable, as demonstrated by the accessibility of a number of on-line retrieval systems (e.g. NLM's MEDLINE) via several such networks.

But ERIC does not have to attempt total networking immediately. It could consider a gradual, piecemeal approach, getting started with several interested clearinghouses (as was done in the experimental study DET-1). Then, with careful planning and interim successes, other ERIC nodes or modules could be tied into an expandable ERIC network. Various non-ERIC resources could thereby also become directly accessible.

Among the specialized kinds of technological resources likely to become available and attractive to a future information network is the computer system tailored to accommodate and process data. The concept of a data base computer [ORT-6, 7] is being developed further and, with the prospects of being coupled with mass storage facilities (discussed in Section 3.1.3.7) and effective associative and parallel processing techniques [e.g. ORT-8], will undoubtedly influence future data base resource sharing.

Before being convinced of all the possibilities in the networking area, other specialized experimental efforts might be desirable. To get a better understanding of potential future levels of data transmission volume that ERIC may wish to accommodate, we must go beyond our implicit assumption (above) that ERIC only needs telecommunication facilities for transmitting relatively low-volume document surrogates plus miscellaneous short, user-input messages (or alpanumeric strings) including on-line search commands. Among the alternatives are: transfer of fairly large files or file segments (perhaps involving surrogates, or statistical data) as well as the transfer of full-sized documents.

If the latter documents are not yet storable in alphanumeric form (until cheaper mass memories become operationally usable), then at least the facsimile transmission of paper copy documents [ORT-9, 10] and also their microfilm images [ORT-11] is possible. Facsimile equipment "copies" alphanumerics and graphics (without "recognition" as such) from a source item by means of scanning it somehow, converting its image to electrical signals, transmitting those over telecommunication lines and then producing a copy of the original at the recipient site.

An example is the experimental effort entitled Federal Library Network Prototype Project involving the NBS Library and 14 other technical and scientific libraries [ORT-12]. Two types of facsimile machines are used. Both are low-resolution systems, leaving something to be desired in resulting image quality. One uses fiber optics to read the document with a photoelectric cell, converts the light and dark areas into electrical impulses, transmits those over Federal Telecommunications Lines to a receiving machine, and reconverts via stylus which burns the dark areas on a titanium oxide-coated paper. The other kind of machine involves slow-scan television, with a camera directed at the document providing light signals which are converted to the audio range, transmitted over the communication lines, and reconverted for display on a still TV picture screen. In either case conventional telephone lines are used and a copy of a document is "delivered" in several minutes. Getting the paper copy sent by ordinary mail, on the other hand, may take days or even weeks.

As the above demonstrates, networking can encompass a number of other data types and communication modes and purposes. They should be taken into account by NIE/ERIC in justifying and designing any future (national and even international) information services network.

4.1.3 Distributed Processing

A network can be regarded as the skeleton or the amalgam which ties together various processing nodes and communication lines to enable collective, applications-oriented operation. The network is then to be supportive of whatever kind of processing is to be carried out and where that is to be done. In particular, if it is designed properly, we can do "distributed processing" as well as distributed data base work in the context of a network.

The literature exhibits many useful papers [e.g. DIP-1, 2] which clarify the definitions and concepts pertaining to distributed processing. Sets of considerations that should go into deciding on "going distributed" [DIP-3] and numerous exemplary applications [e.g. DIP-4] are also to be found. In essence, a distributed processing network provides for the flexibility and many other advantages of performing the data entry, the computer processing, the data base manipulation and the user accessing of computer-based resources "wherever the action is" or wherever it is most convenient and reliable to do so.

Although the term was not used in the previous section on networking, distributed processing was implied by the indicated desirability of having both a logically centralized and decentralized ERIC network structure. It is also in keeping with the earlier discussions (in Section 3) of providing computer-based means such as word processors, as well as certain computer-microfilm composites, at the various ERIC nodes. In particular, the localized use of minicomputer-based systems in a network environment [e.g. DIP-5] is becoming almost synonymous with distributed processing.

Besides doing various kinds of processing locally (e.g. inputting and editing a document surrogate at an ERIC clearinghouse) and subsequent processing at another, perhaps hierarchically higher site (e.g. modification and compilation of a surrogate data base for searching), the special need for effective accommodation of the data base(s) in a network must be acknowledged. If we want to be able to do the processing in the geographical location where it is most convenient and conducive to the application (e.g. where the ERIC subject specialists can render decisions on document entry), then it follows that there may be the logical requirement for a locally available, supportive data base.

This leads us then to discussions of distributed data bases [e.g. DIP-6, 7] and how to keep track of them in a network [e.g. DIP-8]. It also should remind us of the intelligent terminal systems and related storage devices (e.g. floppy disks) described in Section 3. Along that line, even data base management systems for minicomputers are being developed [DIP-9] and are likely to be much improved in the future. Thus, as was suggested by a senior ERIC staff member, the use of a DBMS in support of selected ERIC system functions performed by minicomputer is not to be ruled out.

Finally, distributed processing in its fullest sense represents a kind of interesting convergence [DIP-10] of networking technology with the various component technologies (e.g. minicomputers, intelligent terminals, word processors) to form a locally accessible information system. And, if local accessiblity is really a key factor in the future of the ERIC system, then networking and distributed processing technology is likely to benefit both the ERIC staff (next section) and the ERIC users (Section

4.3) accordingly.

4.2 Staff-Network Interaction

It is a well-known fact that strong differences in opinion remain among information specialists as to the desirability of increased dependence on technology. However, at the same time, we have seen how more and more people (including secretaries in offices) become more and more convinced of and conditioned to the trememdous advantages to be gained.

This is also true of a decentralized system such as ERIC in which the clearinghouse staffs have remarkably different views on and interests in using technology. Some of them are very excited about the prospects; others are at least leary or cautious if not altogether opposed.

In this section we wish to briefly indicate some important characteristics and modes of staff interaction with an ERIC network. Focus here is on the staff members, not on the users. It is highly probable, however, that services experienced by the latter are contingent on the (technology facilitated) well-being of the former.

4.2.1 Characteristics and Criteria

A staff member associated with an information system may generally be characterized as playing a role involving one or more of the following: operational or functional duties (e.g. inputting and outputting data) in conjunction with various locally or remotely available (non-human) information resources and devices, similar duties in conjunction with other locally or remotely available people (staff members, resource persons and/or users), and administrative coordination with, again, locally or remotely available management-level persons. Network facilitation of these roles is highlighted in the next three subsections.

But, before doing so, we should return to the question of how staff personnel regard system or network performance from their particular vantage point. If they directly interface with the information resources, perhaps often playing the specially trying role of serving as intermediary information specialists for the end user, they may be most informed and opinionated about what does or does not work well.

Under efficiency, staff members might be especially sensitive to throughput i.e. how many information items (e.g. surrogates) can be reliably input per time period, or how many copies (e.g. of microfiche) can be made, or how many on-line searches can be carried out, or to how many other staff members can an important procedural change be communicated. Such quantity-oriented interest in turn influences staff ability to achieve adequate "response time" in meeting imposed demands.

Under effectiveness, a staff person is not merely interested in how much can be done but also in what the quality of the resulting products is. Reliable, error-free technology is therefore important. In addition, it should be possible to get good legible copies of documents and well-formatted, presentable search outputs.

Thirdly, staff-related synergism questions tend to involve desirable convenience, ease of use or interaction, and avoidance of such factors as frustration. The last of these can of course apply both to technology and people. These kinds of staff concerns should be kept in mind in reading the next three subsections.

4.2.2 Input/Output Facilitation

A staff member who performs an operational role with regard to an information system can wear two hats. On one hand, he or she carries out assigned staff function(s) which contribute in some way to the system's operation, e.g. in preparing and inputting surrogate data. On the other hand, he/she may in fact be a system "user," not only in support of the above-mentioned operational role but also in behalf of end users who have submitted various information requests.

Under the latter interpretation, namely that of a user, staff members must interface with the existing technology directly and thereby become quite familiar with and concerned about advantages and disadvantages in user-system interaction [see also USI category]. Unlike the average, non-specialist users, experienced staff members are likely to be much more knowlegeable and sophisticatd about the available world of information resources and hence they may be more discriminating and demanding of technology and of how it can more effectively support assigned functional roles.

What then can networking and distributed processing contribute to staff functions? Firstly, by localizing the computer processing and storage devices as necessary (perhaps by means of a word processing configuration tailored to the needs of a particular ERIC node) the staff member should experience considerable facilitation of the data input and editing function. The data can be compiled locally and then, when necessary or desirable, transmitted via the communications network to another (central) site for further processing. It should be noted that a local, minicomputer-based system would not only enable input of surrogate data but also the inputting, processing and packaging of a variety of other useful information products.

The latter is also true on the system output side. If a staff member could access the ERIC network via a local system for purposes of directly getting at a whole repertoire of available information resources (via the network), surely the information search and output functions would be facilitated. Furthermore, the staff person would not have to be faced with an assortment of quite distinct and inconsistent modes and means of getting at information. The results of searching in the distributed processing network (which might easily interface one or more on-line retrieval systems) could, upon receipt, be processed further in the local intelligent node.

In fact, one of the interesting distributed processing possibilities that can be considered is the following: Let the results of a standing query or of an on-line search, initiated by a staff member on the basis of a "general local user interest profile," be transmitted over communication lines to the local floppy disk-based system, and then let the staff members or actual end users search the locally stored data base segment directly. This would not only provide a way of dynamically segmenting the ERIC files, but it might also save communications costs. The local file could be replaced (for current awareness searching) or supplemented (for retroactive search purposes) on a periodic basis. Technologically this is possible. The main problem hinges on whether such a file partition can effectively serve the interests of a local population.

4.2.3 Coordination with Management

Besides facilitating the operational functions assigned to staff personnel, networking and distributed processing would also aid in improving the coordination with and responsiveness to those who are in management, whether centrally or decentrally located.

From the standpoint of management, a computer/communications network can and should be viewed as what it really is: a sociological network of interrelated or interdependent people being superimposed on the technological network [ISC-1]. In particular, this means that a staff person who carries out operational roles in using the technology, and is thereby quite attuned and conditioned to the technological interface to a wide variety of resources, finds it very natural to utilize those same computer/communications-based facilities for purposes of coordinating with and responding to other people, especially his/her management. The latter must of course also be "tied into" the network.

Although the above claim is undoubtedly subject to question by some people, the fact remains that to those persons to whom the technological interface has become a natural, effective part of the everyday operational workstation, it is easier to utilize that same medium for communication with management than to switch to traditional modes such as telephone calls or manually prepared reports. In addition, certain advantages can be identified. These include the abilities to be truly responsive (i.e. sending an answer immediately upon request), to keep management informed as things happen in real time, to schedule the communication/correspondence at one's own convenience (except when personal, direct interaction is required), and even perhaps to remain anonymous when sensitive matters (e.g. criticisms of management policy) may be involved.

4.2.4 Conferencing and Collaboration

The above-implied software for enabling the transmission of messages or electronic mail [ISC-2] between staff and management has become a recognized important feature in state-of-the-art computer systems and networks. It can of course also provide for such communication links between various staff personnel located at different network sites (e.g. for purposes of job-related collaboration) as well as between staff members and users and vice versa. Besides sending each other ordinary variable-length messages or reports, there are also software packages available to support other kinds of modes of communication. These include the well-known Delphi and other types of computer-based conferencing which started to draw attention in the early 1970's [ISC-3, 4].

An important point to be made about people communicating via computer networks is that it should no longer be viewed as unnecessary or luxurious. Instead it might be regarded as a highly desirable byproduct of networking. As long as we have the need for interfacing or integrating the previously mentioned sociological network with a technological resource network [ISC-1], the associated resource people should be able to correspond/collaborate/respond/inform/cooperate conveniently within the context of that network. This should minimally require an effective electronic mail system. The door should also be left open to the future possibility of acquiring a good software package for selected types of more dynamic conferencing which might conceivably involve any or all of ERIC management, staff and even users.

4.3 User-Network Interfacing

If the reason for implementing ERIC was to serve users in the educational community, then the interface between those users and the ERIC technology should be of top-priority concern. Regrettably the users were frequently neglected in the design of earlier computer systems and networks. However, with the recognition that sophisticated computer and communications technology could be developed to respond to almost any information processing/communication needs, computer scientists have become more sensitive to rendering that technology actually "usable" by people.

The USI category of the adjoining bibliography is especially applicable in this section, but several of the equipment categories [e.g. OLT and WPE] and studies involving evaluations of ERIC users and uses [EVA] also have direct pertinence to the user interface.

4.3.1 Characteristics and Criteria

Users of information systems may be characterized along a number of different dimensions, including level of experience, frequency of system use, objectives of use, user preference, level of satisfaction with a system's services and others. In the educational community of users, the diversity of user characteristics is undoubtedly very great.

Ideally, we would like to be able to adapt the technology to the individual needs and wants of users. However, much more research is required to make that a realistic goal for a large population of individually different persons. In the meantime, we can at least attain a compromise solution based on generally desirable, user-oriented design characteristics. With regard to networking, the next several subsections are to highlight selected features accordingly.

Before doing so, we again should ask, as we did for network staff personnel (in Section 4.2.1) how system or network performance is likely to be judged from the user's standpoint. As far as <u>efficiency</u> is concerned, the user is probably most interested in how long it takes to get the requested information. Is the response time in ordering a paper copy document from EDRS adequate? Unless the user must personally pay for it, the cost factor is relatively low in importance.

Secondly, the user wants effective, quality service. Even if the information is made available immediately (i.e. very efficiently), if it is in error or illegible or poorly formatted or excessively verbose, the user will probably be dissatisfied. For example, a teacher who wants to use some table in a report as a class handout tomorrow is unlikely to be happy with a poor-quality copy produced by an inexpensive local microfiche reader-printer. So, efficiency is not good enough. <u>Effectiveness</u> is also essential.

Thirdly, the above two performance categories obviously influence the third. <u>Synergism</u> has particular meaning for users. Besides how quickly and how well the system responds to the user inquiry or request, there are performance-related questions the answers to which are more elusive but nevertheless very germaine. How "friendly" is the network (both with regard to technology and people)?

How "convenient" does it make the user's search for information? How "accessible" is it? The following subsections discuss several major features which relate to such user-oriented networking.

4.3.2 Technological Interface

The technological interface between user and information network can be treated in a dichotomous manner consistent with the organization of this report: firstly, the equipment component (or local node) with which the user must deal directly in order to access and communicate with any of the information resources available in the network, and, secondly, the total network of geographically distributed resource nodes which the user may have to conceptualize and understand.

Some of the user-oriented considerations in providing for a desirable component-level interface were already mentioned in the coverage of computer-based means for input/output of Section 3. The selected literature [USI category] gives further evidence. Our interest here is not to review all of those characteristics. Instead we wish to make an important observation, contingent on the nature and trends of distributed processing networks. The component-level user interface cannot only be made "locally accessible" to the user, in accordance with previously mentioned goals, but it can have more "intelligence" built into it (whether in real or virtual form) to aid the user in overcoming the second part of the above-stated dichotomy, namely the perhaps confusing and overwhelming network on the whole.

That is to say, we can alleviate the problems that users have in being forced to know about a variety of usually inconsistent types of information resources and associated languages by providing them with suitable resource directories, a sensible network-wide interaction language and other special kinds of help. The locally accessible network node should thereby become a convenient, manageable access "window" to the network without concerning the user with its internal structure, control mechanisms and other bothersome details. Although this may still be considered as too idealistic, it surely tends to get us in the direction of the "one-stop shopping center" for users which was advocated (by an ERIC staff member) as a very desirable ERIC goal. The concept of the "one-stop shopping center" does not, for our interests in this study, have to mean that ERIC must own or control all the "stores" in that center. We realize that it may always be necessary for certain information resources (pertaining to the education community) to exist outside of ERIC. But, the inherent nature of networking and distributing processing is such that different information stores, regardless of ownership, can be made directly accessible to users and/or be encompassed in an "information resources directory" which can aid users in determining at least what kind of information is available from what system. One option would be to provide the network users with access to an integrated (multi-organizational and multi-media) search system which would respond only on some surrogate level. The user could then order the referenced documents or other items from the identified source organization (ERIC or non-ERIC).

4.3.3 Modes of Use

One distinction in mode of use of a network of information resources is that between on-line (or interactive) and off-line use (Section 3.2.3.1). Previous studies of ERIC users have suggested increasing interest in the on-line mode [EVA-3]. If possible, a user who has an immediate information need tends to want the information now, not tomorrow and not three weeks from now. Note that this does not mean that the information is necessarily located at a remote site. A locally (floppy-disk) stored file segment, if it contains what the user wants, would be quite satisfactory.

But, the above-implied desirable situation is not attainable by ERIC without overcoming some important problems. Firstly, a distributed processing network of the kind portrayed in this total system-oriented section, coupled with the numerous on-line terminals which could serve as user access nodes, of course costs more money. Secondly, we must not ignore the fact that ERIC remains very much microfiche reproduction oriented which generally connotes "off-line" usage, even though certain orders (for EDRS service) can be placed on-line. The computer-microfilm composite configuration of regional (and even local user) processing nodes, which has been promoted in several places of this report, could complement the on-line and off-line usage modes in such a way that futuristic ERIC network design (including the possibility of mass memory facilities capable of full-document storage) could become increasingly on-line oriented as it becomes more feasible and effective to do so.

4.3.4 Types of Assistance

Presently, ERIC users are relatively on their own, unless they are fortunate to have the services of a knowledgeable intermediary. They can of course find some helpful documentation on how to use ERIC [e.g. see in ERI category] and listings of where the ERIC data base is being maintained as searchable or reproducible. In many smaller organizations and libraries, getting access is undoubtedly a struggle.

In the potential ERIC network environment, the user who is being provided with local accessibility should also get plenty of assistance. This help can take on a number of useful forms including: on-line tutorial description of ERIC, directory to ERIC information resources (as mentioned in Section 4.3.2), on-line help from appropriate ERIC staff members and possibly even coordination via conferencing (Section 4.2.4) with other users who have similar information-seeking problems.

4.3.5 User Feedback

Finally, in user-network interfacing, it must not be forgotten that any vital information system should remain dynamic by continually scrutinizing its design and performance and modifying it to adapt to changing user needs. In addition to other formal self-evaluation techniques [see EVA category], the solicitation of and serious attention to user feedback is crucial.

In a future ERIC network, this means that users should have the mechanisms for easily submitting comments (both good and bad), issuing specific complaints and requesting immediate explanations of exceptional system behaviors (including billings). Computerized mailing and conferencing methods (Section 4.2.4) can be very supportive of this goal.

5. CONCLUSIONS AND RECOMMENDATIONS

In presenting the component- and system-oriented results of our investigation, a number of observations about the current ERIC system as well as both explicit and implicit suggestions on its future technology-based improvement were already indicated. However, to properly complete the report, a composite of our major conclusions and recommendations, placed into the context of other (non-technical) considerations to the extent possible, must be made.

This section is purposely organized in a relatively brief, outline format in order to facilitate its reading. References to selected supportive discussions found elsewhere in the report are made as appropriate.

5.1 Current ERIC Technology

Our conclusions on ERIC-employed technology as it currently exists can be portrayed as follows:

1. ERIC is highly dichotomized in the usage of micrographics and computer technology (see Section 3.1.3.6). This gap, which pervades and influences the entire system, is starting to be bridged with selected efforts, e.g. the use of COM by EDRS and the online ordering of microfiche copies.

2. The micrographics technology that is in use by EDRS is quite good (see Section 3.1.2.5). The percentage of inadequate microfiche has been reasonably low in recent years. Poor quality fugitive documents selected for microfiching do cause problems, and understandably so.

3. On the user end of the microfiche technology, besides above-mentioned difficulties with certain fugitive documents microfilmed, the quality of microfiche readers and reader/printers is subject to serious question. According to a number of sources, such equipment available in the educational community is often cheaply made or poorly maintained or improperly used (see Section 3.2.2.3).

4. The use of computers in ERIC involves an assortment of distinct, relatively independent facilities, organizations and modes. These range from ERIC database preparation (by the ERIC Facility in conjunction with a contracted service) to the on-line search (by ERIC users) of one of the available commercial computerized systems. An overall, NIE/ERIC-controlled or -promoted

computer/communications network as such does not exist (see Section 4.1.2).

5. With regard to <u>computer-associated terminals</u>, a considerable assortment of mostly simple and/or specialized pieces of equipment is in use (see Sections 3.1.3 and 3.2.3). On the input side, ERIC clearinghouses employ devices for OCR (of surrogates) and for that purpose only. Various interactive terminals are used for on-line access and searching of ERIC files in different available systems.

6. <u>Multi-purpose I/O equipment</u>, perhaps supported by some local computer processing and data storage capability, is rare in ERIC. Several exceptional sites have done limited (mostly experimental) work with word processing equipment and other intelligent display stations, as part of an ERIC-sponsored project to determine advantages and costs.

7. ERIC technology and databases are strictly attuned to the <u>processing of visual data</u> (see Section 3.1.1.1). These are predominantly of the alphanumeric variety although some tables and graphs may be included. Audiovisual and other data/media are not accommodated.

8. ERIC technology can only serve a limited <u>data processing purpose</u> (see Sections 3.1.1.3 and 3.2.1.3). Computer-based manipulation and searching is only possible on low-volume items (e.g. surrogates). In accordance with the dichotomy mentioned in 1 above, full sized documents are microfiched, saved, and reproduced upon request. Their texts are not searchable by computer.

9. The above-characterized collective technology of ERIC, as it currently exists, primarily accommodates the needs of information specialists, working in regional information centers or sizable libraries and able to cope with the diversity of independent, inconsistent information sources and media. The technology does not facilitate a uniformized, localized <u>access by end users</u> who represent the bulk of potential ERIC users in the educational community (see Section 4.3).

10. Finally, the current technological make-up of ERIC is surprisingly consistent with the original intentions and plans (see Section 1.1), in spite of many commendable improvements made over the years. One major exception appears to be the lack of

communication technology to tie the pieces of ERIC together and render its resources more directly accessible to more users. Although ERIC users can and do carry out on-line searches of ERIC databases via available communications networks, that cannot be viewed as an adequate substitute for an all-encompassing ERIC-controlled/promoted network, regardless of the supplier of the communication services (see Section 4.1).

The above-stated conclusions were drawn given full recognition of what appears to be the NIE/ERIC philosophy of retaining a decentralized, wholesale-retail approach to the ERIC system. Nevertheless, since we were asked to consider how technology could improve ERIC, we feel obliged to point out that a centralized impetus or initiative towards encompassing ERIC resources in a more integrated, accessible manner is necessary to gain major potential benefits. At the heart of such efforts would undoubtedly have to be the application of state-of-the-art computer/communications technology coupled with distributed processing. As is observed later, this does not have to mean elimination of the above-indicated philosophy in favor of highly centralized management and control by ERIC.

5.2 State-of-the-Art Technology

Costs of computer hardware are going down significantly. This trend, combined with increased capabilities and decreased sizes of mini- and micro-computers, virtually assures the ever more popular and prevalant uses of computers in our society and even in our homes. Even information-seeking, nonspecialist users of ERIC may be affected.

Communication costs are also dropping, although not as rapidly as those for computers. The communications technology exhibits a considerable variety of effective and reliable techniques and disciplines for sharing communication lines and devices. Furthermore, the interfacing of computers and communications media has resulted in very attractive data transmission and processing arrangements and networks.

Given this brief backdrop of the state-of-the-art of computer/communication technology, our conclusions which specifically apply to ERIC are as follows:

1. With regard to the microfilming branch of the ERIC technological dichotomy, no significant enhancements are currently available or foreseen in the near future, short of coupling or cross-fertilization with computers. This is

partly, and regrettably, due to the fact that research and development in the micrographics area is not nearly as intensive and potentially lucrative as in the area of computers and communications, especially when the (relatively poor) educational community is involved as a part of the market.

2. As a corollary to 1 above, better microfiche readers and reader/printers are available than those which are apparantly (or allegedly) utilized by many ERIC users. But they tend to be more expensive and hence less likely to be affordable by educators (than by persons in business or industry).

3. As was stated by a number of persons contacted in conjunction with this study (both within and outside of ERIC), we already have the necessary technology on hand. The technology for significant improvements of ERIC is already available; we must only determine how to apply it most advantageously and, of course, how to support its application financially.

4. Until and unless mass storage technologies become operationally available and viable alternatives to full- document storage on microfiche, a closer coupling or integration of micrographics and computer technologies is both posssible and desirable for ERIC (see Section 3.1.4 and 3.2.4).

5. Mini- and micro-computer based intelligent terminals are available for multi-purpose application (including above-suggested coupling with micrographics and also replacement of OCR input, if desired). These could be utilized at ERIC clearinghouses and other information centers (see Secion 3.1.3.5). However, such systems may not be viewed as cost effective by most ERIC-associated sites until or unless they are regarded as a form of distributed processing which, when placed into the context of a network, can precipitate or produce important other benefits.

6. As implied by 5, the interconnection of ERIC processing nodes (including the clearinghouses, the Facility, and EDRS) into a distributed information network is a distinct technological possibility (see Section 4.1.3). Other resources such as on-line search systems and future database computers could also become accessible via that network. With regard to choice of communication support, the current technology provides a number of alternatives (see Section 4.1.2).

7. Not only could ERIC staff and management benefit from the above (see Section 4.2), but, above all, the ERIC users could experience the sought-after local accessibility to the technologically facilitated ERIC resource network. User access could be via local terminals, whether simple or intelligent, which could tie into one of the established intermediary nodes in the network.

Current state-of-the-art technology can support the above portrait of what ERIC might become. While computer and communication cost trends are favorable, a major effort to change ERIC could nevertheless be quite costly and hence require considerable commitment. In view of that and given our understanding of NIE/ERIC thinking about ERIC and its mission, it should be pointed out that different approaches or strategies for technology-based improvement of ERIC exist and should be considered.

5.3 Approaches to Improvement

It does not have to be an "all or nothing at all" proposition for NIE/ERIC. The cost of going all out immediately would most certainly seem prohibitive. Hence, a number of factors should be taken into account.

Firstly, for whatever option is chosen from among those outlined in the next section, more detailed specifications will be required based on further study expressly focussing on that option. As was stated early in this report, our study was not expected to arrive at design specifications. Consistent with this clear need for more information (e.g. on projected data flow rates among ERIC nodes), a gradual approach to achieving a distributed processing network in the future may be preferred. This approach might generally entail the following:

1. Capitalize on existing interest/expertise available in selected clearinghouses with regard to use of word processing equipment and intelligent terminal systems. Foster and promote this kind of interest and support carefully planned experimental efforts to determine more specific ERIC requirements.

2. In like manner to 1, promote/support selected efforts to interconnect pairs or clusters of processing nodes for purposes of well-structured testing of inter-node communication possibilities.

3. In addition, enable node connection with the ERIC Facility (and possibly EDRS) for surrogate and other input as well as to serve other functions, over longer periods of time than what was

applicable to the 1978 experimental study [DET-1].

4. In the process of the above steps, develop well-documented "models" of suitable, cost-effective node configurations which can subsequently be copied by other ERIC nodes after they become convinced, having observed successful operation elsewhere.

5. Ultimately, the above-suggested building-blocks approach could lead to a distributed network encompassing all ERIC nodes plus other resource centers and of course also user access stations.

The advantages of such a gradual, stepwise approach include flexibility and freedom to try out and test different kinds of equipment with the possibility of arriving at several kinds of processing nodes tailored to somewhat different sets of purposes. A disadvantage is that it might take a long time before agreement is reached and before anything resembling a true integrated ERIC network is implemented.

It must be noted, furthermore, that the above approach must be carefully planned and centrally directed in order to promise success. Among other problems, whenever a number of parts of a "system" are allowed to develop too freely without guidance on how to relate to others, the (in)compatibility results may be disastrous. This is merely to suggest that a deliberate, long-range attempt to introduce networking and distributed processing to ERIC must be undertaken. It should be monitored by a competent staff of technologists who remain up-to-date on such matters as computer-communication interfacing techniques and standards. Simultaneously, the central leadership should take very visible steps towards stimulating and training current/potential ERIC users in the effective use of the technology for purposes of achieving early and widespread user acceptance.

Finally, if improvements to ERIC are to be expedited (compared to the gradual approach suggested above), the problem with adequate funding remains.

5.4 Range of Available Options

After all is said and done in an investigation like this, the "bottom-line" question that must be asked is: What, then, are the choices available to NIE/ERIC and how do they compare in terms of potential benefits and costs?

Detailed analyses and comparisons of cost were not feasible in this study. The heterogeneous, decentralized nature of current ERIC, its diverse proessing sites, its limited state of technology and its irregular usage characteristics render any credible attempt at projecting cost figures for future ERIC configurations a substantial effort. While that is recommended among possible follow-on studies (see Section 5.6), it could not be encompassed in our work. Nevertheless, the following outline of seven major options for technology- based improvement of ERIC is arranged in order of generally increasing costs and correlated benefits. The increases are mostly cumulative due to one option being prerequisite to another. The interrelationships are made evident below.

1. LEAVE THE ERIC DESIGN ESSENTIALLY AS IS AND CONCENTRATE ON SELECTED IMPROVEMENT of one or more of its technological components and uses thereof.

    a. In micrographics at EDRS: use of diazo instead of vesicular film; further tightening of quality control in microfilming/processing; clear, individualized identification of poor quality original documents; greater coupling with computers, e.g., with COM (thereby encouraging other computer-based options below).

    b. On document input: finalization of reproducibility guidelines; guidelines for control of original document preparation, perhaps using word processing computers (again precipitating later options below).

    c. On ERIC Facility software: improvement of its logical capabilities and efficiency, in conjunction with the contracted computer service (an option which is possible but unlikely to reap major new benefits for users under present ERIC design); increased word processing power to facilitate editing/handling of surrogates supplied by the clearinghouses; use of mini-computer based DBMS.

    d. On the ERIC database: enabling other kinds of educational resources (e.g., audiovisual materials) to be referenced at the surrogate level, even if the information media themselves (e.g., movies) are not directly controlled by ERIC.

e. On microfiche readers and reader/printers: promotion/support of better quality equipment made available to ERIC users; publicity and training of users to achieve more effective use and wider acceptance.

2. Besides Option 1, REPLACE OR SUPPLEMENT THE SINGLE-PURPOSE OCR EQUIPMENT IN CLEARINGHOUSES WITH MULTI-PURPOSE WORD PROCESSING SYSTEMS. These systems could be of different configurations, tailored to the particular needs of respective ERIC sites. Initial emphasis would be on more effective autonomous operations. However, the capabilities and intercompatibilities for node-to-node communication should be assured, just in case this choice leads to Option 5 below.

3. Besides Options 1 and 2, ANTICIPATE OPERATIONAL AVAILABILITY OF A MASS DATA STORAGE AND SEARCH CAPABILITY to better accommodate the ERIC data bases. Among the more promising technologies are videodisk and the data base computer. With the possibility of such technology assuming some (or all) of the full-document storage function currently served by microfiche, functional modularity in ERIC design is highly desirable. This applies especially to efforts towards coupling or blending micrographics with computer-based means (e.g. in Option 4). Furthermore, it is quite likely that future availability of such a mass storage facility will naturally precipitate interest in on-line accessibility and hence the networking option 6 described below.

4. Beyond Option 2, PROMOTE MULTI-PURPOSE, COMPUTER-BASED NODES AT ALL ERIC-ASSOCIATED INFORMATION CENTERS, including clearinghouses and user organizations. These nodes can be complemented and modularily coupled with micrographics equipment. Emphasis would be on relatively autonomous use of such intelligent local systems. However, they could occasionally be linked into other facilities, e.g. for general ERIC data base searching (in some on-line retrieval system) leading to local storage and searching of resulting file segments.

5. Based on Option 2 or 4, INTERCONNECT THE INFORMATION PROCESSING NODES via telecommunication facilities,

   a. With the ERIC Facility node
   b. With EDRS and/or a data base computer (Option 3)
   c. With each other

This could be done in a gradual manner starting with pairwise links where the data traffic is adequately high. The relatively autonomous independent operation of Options 2 and 4 would lead to increased technology-based interdependence, with concomitant advantages to be gained in terms of more coordinated and effective support of ERIC.

6. Based on Option 5, DEVELOP A FULL-SCALE COMPUTER/ COMMUNICATIONS NETWORK FOR THE EDUCATIONAL COMMUNITY. The nodes would be the multi-purpose, small-computer based stations of the clearinghouses and of various regional information processing centers. Accessible resource nodes would also include the ERIC Facility, one or more on-line search systems providing the entire ERIC data base, EDRS for use of COM and ordering of hard copies (maybe also with facsimile transmission), and perhaps a future data base computer with mass memory (based on Option 3) providing (selected) full-text documents in computerized form. This network could also accommodate the useful forms of management/staff/user communication and conferencing.

7. Capitalizing on Option 6, ENCOURAGE AND SUPPORT WIDESPREAD AVAILABILITY OF LOCAL USER TERMINALS AND DEVELOPMENT OF USER-ORIENTED NETWORK INTERFACE SOFTWARE. While Option 6 focusses on the technology of the resources network itself, this option emphasizes the essential ultimate objective of providing facilitated "local user accessibility" to the information resources. These user terminals could either be tied into the nearest regional information center and be controlled from there, or they might be linked into a fully distributed (value added) type of communications network. In any case, although such extensive user access may appear to be exceedingly costly, if the information resources network is attractive enough, much if not all of the local terminal and communications costs are likely to be born by the users or the user organizations. Expected substantial increases in numbers of home computers, tied into television and telephone devices, will serve to enhance that prospect.

Thus, we have reached the final stage in the above-listed sequence of interdependent options. The technology is already here to support such recommended efforts, which probably will be viewed as too costly or too idealistic or too futuristic or too technology-oriented to suit the present tastes of many people in the educational community. But, consider the alternatives. Think ahead to the year 2000 or even only 1990. With computers and telecommunications becoming increasingly prominent and vital in all sectors of our society, and with present-day students and many of their teachers becoming more and more educated in and sensitized to information processing/ transmission technology, the current highly dichotomized and locally "inaccessible" design of the ERIC system will surely be viewed as inadequate by the education community.

The idea of providing users with local accessibility by emulating a "one stop shopping center" at which (regardless of who owns the stores) the shopping for all available types of educational data, resources and media can be carried out, is no longer far-fetched. It can be done, although it takes time and money to do so. But, with enough foresight and careful planning, given the centralized leadership to stimulate/promote/support the effort and with the decentralized capability and enthusiasm to respond to such leadership, ERIC could perform in a significantly improved manner one decade from now.

The above portrait of what is technologically possible must be realistically qualified. The current NIE/ERIC management philosophy appears to be banked on 1. decentralization (letting clearinghouses and information centers do things largely on their own initiatives), 2. the wholesale-retail concept (and not wanting to adopt or control or compete with ERIC-associated functions presently served by commercial organizations), 3. a general realism (if not pessimism) about prospects for achieving major increases in Federal funding of ERIC (and hence being unable to support many of the technology-based improvements at the information centers and user sites), 4. the view of the ERIC mission as much more limited (e.g. to fugitive textual documents and their preservation) than what many other people see or would like to be true, and finally, 5. the interest in maintaining the desirable characteristic of ERIC, namely its acknowledged stability (as opposed to undertaking major innovative efforts which could perturb the system). In addition, a general feeling seems to persist suggesting that the educational community either does not want or is not ready for too much more technology.

If that philosophy is retained, and perhaps it should be, then the lower-numbered options (1 and maybe some of 2 and 3) are most appropriate and most likely to be pursued. There is no question, however, that resulting, selected improvements and user-seen benefits will be strictly limited. If, on the other hand, the more advanced computer/communications technology is to be more fully and favorably applied to ERIC (through Options 4 through 7), at least some of the above-stated views will have to be modified.

5.5 Suggested Follow-Ups

Among the results expected from this investigation was an indication of desirable, specialized follow-up efforts (Section 1.3) which could carry out detailed analyses and/or produce actual design specifications. With reference to the seven major options outlined in Section 5.4, the following studies are recommended as potentially fruitful. The list is not exhaustive.

1. For Option 1:

   a. A feasibility study to determine how and when ERIC might be able to better control or influence original document preparation towards overcoming current problems with fugitive documents.

   b. A study to determine how a versatile, mini-computer-based system (connectible to one or more larger computerized information services as well as EDRS) could support and enhance the functions of the ERIC Facility.

   c. A feasibility study on the implications and required resources for accommodating other educational resources, such as videotape, at the surrogate level of the ERIC database.

   d. A study to determine specific means and methods for promoting the use of improved microfiche readers and reader/printers by ERIC users and for conducting appropriate user training.

2. For Options 2 and 4:

   A study to determine several model minicomputer-based configurations to serve the different classes and volumes of information processing carried out at ERIC clearinghouses and other information centers. These models should include specification of equipment alternatives and costs.

3. For Option 3 (in relation to Options 2 and 4):

   A study to determine specific methods for the effective coupling of computers and micrographics equipment at ERIC clearinghouses and other information centers. Emphasis should be on modular design with the explicit purpose of future replacement of selected microfilm functions with mass memory technology.

4. For Option 5:

A study to determine current and projected data traffic loads and patterns between/among ERIC information centers and resource sites. The full range of operational, computer-to-computer, terminal-to-computer, and person-to-person types and modes of communication should be taken into account. A clear profile of ERIC data transmission requirements should result. Another study, perhaps coupled with the above, to determine the specific types of telecommunication services, vendors and costs which could accommodate the present and future ERIC data transmission requirements most effectively and efficiently.

5. For Option 6:

A study, possibly related to those for Option 5, to determine the most suitable computer/ communications network structure(s) and form(s) of control for the particular geographically separated nodes of ERIC.

6. For Options 5 and 6:

A study to provide effective guidance and consultation to NIE/ERIC on how gradual interconnection of ERIC nodes can be achieved consistent with and/or in anticipation of computer/communications interfacing requirements and standards. This would be intended to preclude incompatibility problems due to independently implemented computer facilities at various ERIC sites.

7. For Option 7:

A study to consider realistic technological alternatives and costs for localized interfacing of present/potential users to an ERIC network, with the expressed purpose of providing the analogy to a "one-stop shopping center."

BIBLIOGRAPHY Categories

CAN: Communication and Networking

1. LeGates, J. "The Lessons of EIN," EDUCOM Bulletin, Vol. 7, No. 2, Summer 1972, pp. 18-20.

2. Heller, P. S. (Ed.) "EDUNET NEWS," EDUCOM Bulletin Vol. 14, No. 2, Summer 1979, 6-page Insert.

3. Chou, W. "Computer Communication Networks--The Parts Make Up the Whole," 1975 National Computer Conference, AFIPS, pp. 121-128.

4. Gerla, M. and Eckl, J. "Moving Bits by Air, Land, or Sea,"1975 National Computer Conference, AFIPS, pp. 129-135.

5. Wood, H. M.,Watkins, S.W., and Cotton, I.W., Annotated Bibliography of the Literature on Resource Sharing Computer Networks (Revised), National Bureau of Standards Special Publication 384, September 1976, 173 pp.

6. Blanc, R. P. Review of Computer Networking Technology, National Bureau of Standards Technical Note 804, January 1974, 128 pp.

7. Cotton, I. W. Computer Network Interconnection: Problems and Prospects, National Bureau of Standards Special Publication 500-6, April 1977, 73 pp.

8. Cotton, I. W. Local Area Networking, Report on Workshop Held at National Bureau of Standards, NBS Special Publication 500-31, April 1978, 74 pp.

9. Computer Networking Symposium, Published Proceedings, Sponsored Jointly by the National Bureau of Standards and the IEEE Computer Society, December 13, 1978, 137 pp.

See also DIP category.

CMC: Computer-Microfilm Composite

1. Harrison, T. L. "CRT vs COM-Real Time vs Real Enough Time," Journal of Micrographics, Vol. 7, No. 1, September 1973, pp. 37-44.

2. Brown, C. O. Jr. "Computer Output Microfilm and the State Archivist: Opportunity and Responsibility," Journal of Micrographics, Vol. 9, No. 1, September 1975, pp. 37-41.

3. Shanks, D. S. "Microfiche: A Changing Profile," Journal of Micrographics, Vol. 11, No. 5, May/June 1978, pp. 325-327.

4. COM Standards: ISO/5126-1978 Computer Output Microfiche (COM)/Microfiche A6; ANSI/NMA/MS2-1978 Format Coding for Computer Output Microfilm.

5. Griffith, A. K. "From Gutenberg to GRAFIX I-- New Directions in OCR," Journal of Micrographics, Vol. 9, No. 2, November 1975, pp. 81-89.

6. Kneitel, A. M. "Micrographics . . . and the Challenge by On-Line Interactive Terminals," Journal of Micrographics, Vol. 9, No. 3, January 1976, pp. 109-113.

7. Lawson, R. L. "A Bright Idea--An Integrated COM and On-Line CIS," Journal of Micrographics, Vol. 9, No. 4, March 1976, pp. 165-167.

8. Goddard, M. C. "An Audiovisual Terminal for Computer- Assisted Instruction," Journal of Micrographics, Vol. 9, No. 4, March 1976, pp. 147-153.

9. Kalthoff, R. J. "Document vs. Data Based Information Systems," Journal of Micrographics, Vol. 10, No. 2, November 1976, pp. 79-88.

DET: Data Entry Techniques

1. Brown, P. D., Cyr, R. and Whitford, C., A Study of Alternative Modes of Data Entry for the ERIC Data Base, Final Report on the Direct Data Entry Project (SIP-78-2), Contract No. 400-76-0031, 1978.

2. Comptroller General of the United States New Ways of Preparing Data for Computers Could Save Money and Time and Reduce Errors, Report to the Congress of the United States, GAO, FGMSD-78-39, July 18, 1978.

3. See also OCR, OLT, and WPE categories.

DIP: Distributed Processing

1. Booth, G. M. "Distributed Information Systems," 1976 National Computer Conference, AFIPS, pp. 789-794.

2. Kallis, S. A. Jr. "Networks and Distributed Processing," Mini-Micro Systems, March 1977, pp. 32-40.

3. Moore, W. G. Jr. "Going Distributed," Mini-Micro Systems, March 1977, pp. 41-48.

4. Severino, E. F. "Using Distributed Processing," Computer Decisions, May 1977, pp. 46-50.

5. Lane, M. G. "The Flexibility of Minicomputers in the West Virginia Network for Educational Telecomputing," International Conference on Computer Communications, 1976, pp. 194-200.

6. Hunter, J. J. "Distributing a Database," Computer Decisions, June 1976, pp. 36-40.

7. Champine, G. A. "Six Approaches to Distributed Data Bases," Datamation, May 1977, pp. 69-72.

8. Chu, W. W. "Performance of File Directory Systems for Data Bases in Star and Distributed Networks," 1976 National Computer Conference, pp. 577-587.

9. Boylan, D. "Minicomputer DBMS: Less than Meets the Eye," Computer Decisions, January 1977, pp. 50-54.

10. Stefferud, E. "Convergence of Technologies Points toward the Automated Office," Trends and Applications: 1978 Distributed Processing, sponsored by National Bureau of Standards and IEEE Computer Society, pp. 6-11.

11. See also CAN category.

ERI: ERIC Description

1. Marron, H. "ERIC . . .A National Network to Disseminate Educational Information," Special Libraries, Vol. 59, No. 12, December 1968, pp. 775-782.

2. ERIC Processing and Reference Facility, ERIC Systems Improvements, A Cumulative List of Significant Changes to the ERIC System, 1966-1979. April 1979, 12 pp.

3. McCarthy, T. S. "ERIC: Organizing Educational Materials," American Education, August/September 1974.

4. National Institute of Education, ERIC--How to Use It, Washington, D. C. 20208 (Undated Pamphlet), 20 pp.

5. National Institute of Education, ERIC--A Profile, Washington, D. C. 20208 (Undated Pamphlet), 12 pp.

6. Brown, J. W., Sitts, M. K., and Yarborough, J. ERIC: What It Can Do for You/How to Use it Stanford Center for Research and Development in Teaching, Stanford U.; Pub. by National Institute of Education, January 1977 (Revised), 19 pp.

7. Brandhorst, T. Characteristics of the ERIC Data Base, ERIC Processing and Reference Facility, Bethesda, MD, Distributed at the Workshop on On-Line Systems and Data Bases, U. of Pittsburgh, April 1977, 79 pp.

8. ERIC Processing and Reference Facility, Data Processing System Documentation and Operating Procedures Manual (for ERIC), June 2, 1969. Supplemented by Update Notices and Documentation (for ERIC Tape Users) produced since then. Supplied by P. Brown.

EVA: Evaluation Studies

1. Frye, B. M. Evaluation Study of ERIC Products and Services, Final Report (4 Volumes and Summary Volume), Indiana University, Project No. BR 00375, Grant No. OEC-0-70-3271, March 1972.

2. Steiger, J. M. Report and Guidelines on Improving the Retrieval of Product Information from ERIC, Final Report, Steiger, Fink and Smith, Inc., NIE Order No. NIE-P-75-0050, October 1975.

3. Havelock, R. G. ERIC Evaluation: 1969 to 1977, U. of Michigan, Sponsored by National Institute of Education, Draft Report, 1978.

4. Pyke, T. N., Jr., Treu. S. and Hudson, J. A. Performance Measurement of Interactive Graphics Systems in Support of Computer Aided Design and Engineering,, National Bureau of Standards Report No. 10 451, Sponsored by U. S. Army Electronics Command, Contract No. 71-96088, June 1971.

5. Treu, S. "Testing and Evaluation--Literature Review," ELectronic Handling of Information, Thompson Book Co., 1967, pp. 71-88.

6. Welch, J. T., Jr., Treu, S. and Camerata, P. The Application of an Associative Memory to Chemical Information Storage and Retrieval, Goodyear Aerospace Corp., GER 13224, Report on NSF Contract C-456, April 14, 1967.

7. Taulbee, O. E., Welch, J. T., Jr. and Treu, S. Testing and Evaluation of the FTD System, Goodyear Aerospace Corp., GER 13099, Final Report on Contract AF 30(602)-4039, March 15, 1967.

8. See Also DET-1.

ISC: Inter-Staff Coordination

1. Taulbee, O. E., Treu, S. and Nehnavagsa, J. "User Orientation in Networking," National Computer Conference,, 1975, pp. 637-644.

2. Walshe, A. W. "Electronic Mail Diversifies with Technological Innovations," Word Processing World, Geyer-McAllister Publications, April 1979, pp. 15-22.

3. Turoff, M. "Delphi and Its Potential Impact on Information Systems," Fall Joint Computer Conference 1971, pp. 317-326.

4. Turoff, M. "PARTY-LINE and DISCUSSION--Computerized Conference Systems," Computer Communication: Impacts and Implications, ICCC 1972, pp. 161-171.

5. Hiltz, S. R. and Turoff, M. The Network Nation: Human Communication Via Computer, Addison-Wesley, 1978, 528 pp.

MFF: Microfilm and Fiche

1. Costigan, D. M. "A Fresh Look at Micrographic Nomenclature," Journal of Micrographics, Vol. 9, No. 6, July 1976, pp. 291-293.

2. Rice, E. S. Fiche and Reel, Xerox University Microfilms, Ann Arbor, Mich., Revised 1972, 22pp.

3. DATAPRO Research Corporation, "Microfilm Cameras," A10-501-101 to 103, June 1978.

4. DATAPRO Research Corporation, "Microform Readers and Terminals," A10-502-101 to 109, June 1978.

5. McCamy, C. S. "On the Information in a Microphotograph," Applied Optics, Vol. 4, No. 4, April 1965, pp. 405-411.

6. Bagg, T. C. "Factors Dictating Characteristics of Systems Utilizing Microforms," Journal of Micrographics, Vol. 3, 1970, pp. 143-146.

7. Fromm. H. J. "An Improved Method of Exposure Control for Black and White Microfilm," Journal of Micrographics, Vol. 6, No. 6, July 1973, pp. 253-258.

8. Bagg, T. C. "Resolving Power Chart for Determining Quality of Microimages," Monogram, National Bureau of Standards, August 1967, 6 pp.

9. Avedon, D. M. "Standards: The Quality Index Method," Journal of Micrographics, Vol. 8, No. 3, January 1975, pp. 139-140.

10. CMIC, Documentation of its Microfilming, Fiche Production, and Hard Copy Production, Prepared for NIE under Contract No. C-74-0112, October 1978.

11. Liston, D. M., Jr., and Howder, M. L. Document Reproducibility Guidelines, ERIC Processing and Reference Facility, NIE, November 1978.

12. Letters to the Editor, "Microfiche, ERIC, and Quality...," Library Journal, written respectively by M. L. Howder (ERIC), A. C. Tannenbaum (NYU) and A. Horder (Hatfield Polytechnic, England), November 15, 1978, pp. 2273-2274.

13. Jezierski, K. Writer's Guide to Publication Development, National Center for Research in Vocational Education, Columbus, Ohio, February 1978.

14. British Standards Institute, "Recommendations for Preparation of Copy for Microfilming," Document 5444.

15. DeSimone, A. A. "Guidelines for Copy Preparation for Microfiche," NASA.

16. Eastman Kodak, "Materials for Visual Presentation, Planning and Preparation," Pamphlet S-13.

17. Bagg, T. C. "A Technological Review: The Future of Microimagery in the Library," Drexel Library Quarterly, Vol. 11, No. 4, October 1975, pp. 66-74.

18. Bassett, E. P., Jr., "The Future of Micrographics," Journal of Micrographics, Vol. 9, No. 6, July 1976, pp. 279-281.

19. Conners, R. J. "The Next Five Years in Micrographics," Journal of Micrographics, Vol. 11, No. 3, January/February 1978, pp. 153-154.

20. Lee, L. S. "R.E.S.T.--Reader Evaluation and Selection Techniques, Part I," Journal of Micrographics, Vol. 11, No. 6, July/August 1978, pp. 339-345.

21. Lee, L. S. "R.E.S.T.--Reader Evaluation and Selection Techniques, Part II," Journal of Micrographics, Vol. 12, No. 1, September/October 1978, pp. 13-17.

22. Editorial Notice, "ERIC Withdraw Silver Fiche Option: Another Set-Back for Microfiche Quality?" Reprographics Quarterly, Winter 1978/79.

<u>OCR</u>: Optical Character Recognition

1. Strelau, C. A. and Schantz, H. F. "The Evolution of OCR Equipment in Total Data Entry Systems," <u>OCR Today</u>, Vol. 1, No. 1, April 1977, pp. 12-13.

2. Shepard, D. H. "OCR--State of the Art," <u>OCR Today</u>, Vol. 1, No. 1, April 1977, pp. 19 and 34.

3. Schantz, H. F. "Optical Character Recognition: The Impact of a Maturing Technology on Future User Applictions," <u>OCR Today</u>, Vol. 1, No. 3, November 1977, pp. 6, 7 and 25.

4. Schantz, H. F. "Economic Considerations in the Selection of OCR Systems," <u>OCR Today</u>, Vol. 2, No. 1, May 1978, pp. 19-22.

5. Rogoff, M. "OCR--Its Promise in Word Processing," <u>OCR Today</u>, Vol. 2, No. 1, May 1978, pp. 12-14.

6. See also DET category.

<u>OLT</u>: On-Line Terminals

1. Axner, D. H. and Reagan, F. H. "Teleprinter Terminal Survey," <u>Datamation</u>, Vol. 24, No. 5, May 1978, pp. 232-255.

2. Granholm, J. W. "Interactive Hardcopy Terminals," <u>Datamation</u>, Vol. 21, No. 11, November 1975, pp. 51-61.

3. Granholm, J. W. "Alphanumeric Display Terminals," <u>Datamation</u>, Vol. 22, No. 1, January 1976, pp. 40-52.

4. Whiting, J. and Newman, S. "Microprocessors in CRT Terminals," 1975 <u>NCC Proceedings</u>, AFIPS, pp. 41-45.

5. Stiefel, M. "What is an "Intelligent" Terminal?" <u>Mini-Micro Systems</u>, March 1977, pp. 50-60.

6. Bitzer, D. L. and Slottow, H. G. "The Plasma Panel--A Digitally Addressable Display with Inherent Memory," <u>Fall Joint Computer Conference 1966</u>, Spartan Books.

7. See also USI category.

ORT: Other Relevant Technology

1. Warnar, R. B. J., Calomeris, P. J. and Recicar, S. A. Computer Peripheral Memory System Forecast, National Bureau of Standards, Special Publication 500-45, April 1979, 136 pp.

2. Warnar, R. B. J. and Calomeris, P. J. Foreign and Domestic Accomplishments in Magnetic Bubble Device Technology, National Bureau of Standards, Special Publication 500-1, January 1977, 42 pp.

3. Braun, L. Microcomputers and Video Disc Systems: Magic Lamps for Educators, SUNY at Stony Brook, Report prepared for the NIE (undated).

4. Winzer, G. "Some More Reasons for the Failure of Holographic Character Reading," International Optical Computing Conference, April 1974, pp. 9-13.

5. Gillis, A. K., Hoffman, G. E. and Nelson, R. H., "Holographic Memories--Fantasy or Reality?" 1975 NCC, pp. 535-539.

6. Marill, T. and Stern, D. "The Datacomputer--A Network Data Utility," 1975 NCC, pp. 389-395.

7. Anderson, D. R. "Data Base Processor Technology," 1976 NCC, pp. 811-818.

8. Butcher, K. E. "STARAN Parallel Processor System Hardwae," 1974 NCC, pp. 405-510.

9. DATAPRO Research Corporation "Facsimile," S33-010-101 to 109 (Description), S33-010-201 to 218 (Suppliers), July 1976.

10. DATAPRO Research Corporation "The Role of Facsimile in Office Communications," A10-400-101 to 118, December 1978.

11. Hopkins, W. L. "Microfiche Image Transmission System (MITS)," Journal of Micrographics, 1978, pp. 83-88.

12. "Experimental Network Links 15 Libraries," NBS Standard, Vol. 23, No. 18, September 6, 1978, pp. 1 and 6.

USI: User-System Interaction

1. Bennett, J. L. "The User Interface in Interactive System," Annual Review of Information Science and Technology, Ed. by C. Cuadra, Vol. 7, 1972, pp. 159-96.

2. Martin, T. H., Treu, S. and Carlisle, J. "The Use Interface for Interactive Bibliographic Searching: An Analysis of the Attitudes of Nineteen Information Scientists," Journal of the American Society for Information Science, March/April 1973, pp. 142-147.

3. Treu, S. (Ed.) User-Oriented Design of Interactive Graphics Systems, ACM/SIGGRAPH Workshop, Pittsburgh, PA, Partially supported by NSF Grant MCS 76-16603, 1977.

4. Treu, S. A Computer Terminal Network for Transparent Stimulation of the User of an On-Line Retrieval System,, National Bureau of Standards, TN 732, July 1972.

5. Abrams, M. D. and Treu, S. "A Methodology for Interactive Computer Service Measurement," Communications of the ACM, Vol. 20, No. 12, December 1977, pp. 936-944.

6. Treu, S. "Conceptual Framework for the Searcher-System Interface," Interactive Bibliographic Search: The User/Computer Interface, Ed. by D. Walker, AFIPS Press, 1971, pp. 53-66.

7. Bourne, C. P., Robinson, J. and Todd, J. Analysis of ERIC On-Line File Searching Procedures and Guidelines for Searching, Lockheed Palo Alto Research Lab, Final Report under NIE Contract No. OEC-0-71-2559, November 1974.

WPE: Word Processing Equipment

1. DATAPRO Research Corporation "Current Word Processing Systems," A10-200-101 to 115 (The Current Office), June 1978.

2. DATAPRO Research Corporation "Word Processing Systems:"
S13-040-100's (Description), January 1978,

S13-040-200's (System Vendors), June 1978,
S13-040-300's (Standalone Systems), June 1978,
S13-040-400's (Shared-Logic Systems), May 1978,
s13-040-200's (TS Service Vendors), July 1978,
S13-050-300's (Time-Shared Services), July 1978.

3. Wohl, A. D. "What's Happening in Word Processing," Datamation, Vol. 23, No. 4, April 1977, pp. 65-74.

4. DATAPRO Research Corporation "How to Select a Word Processor," A33-500-101 to 114, June 1978.

5. DATAPRO Research Corporation Automated Office Solutions, Loose-Leaf Volume, McGraw Hill, 1978/1979.

6. Seybold Publications The Seybold Report on Word Processing, Vol. 1, No. 11, December 1978.

7. Kleinschrod, W. A. Management's Guide to Word Processing, Dartnell Corp., 1975, 275 pp.

8. See also DET-1 and Det-2.

SUBJECT INDEX

(Technological Terms)

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Results of a one-year, NIE-sponsored study to identify potential technology-based improvements in the operation, access, and utilization of the Educational Resources Information Center (ERIC) are described. Both current problem areas and future possibilities are considered with regard to the dichotomy: system components and the total system. Emphasis is on characterizing the component functions of data input and data output as well as the total system operation in terms of applicable criteria (data type, volume, purpose, performance). Technological alternatives are then discussed with reference to those criteria. The report concludes with a structured summary of observations, recommendations, and possible follow-up studies.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Educational Resources Information Center (ERIC); information systems; micrographics; microfiche; computer technology; communications technology; data entry; optical character recognition; computer networks; distributed processing; intelligent terminals; mass storage technology.

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