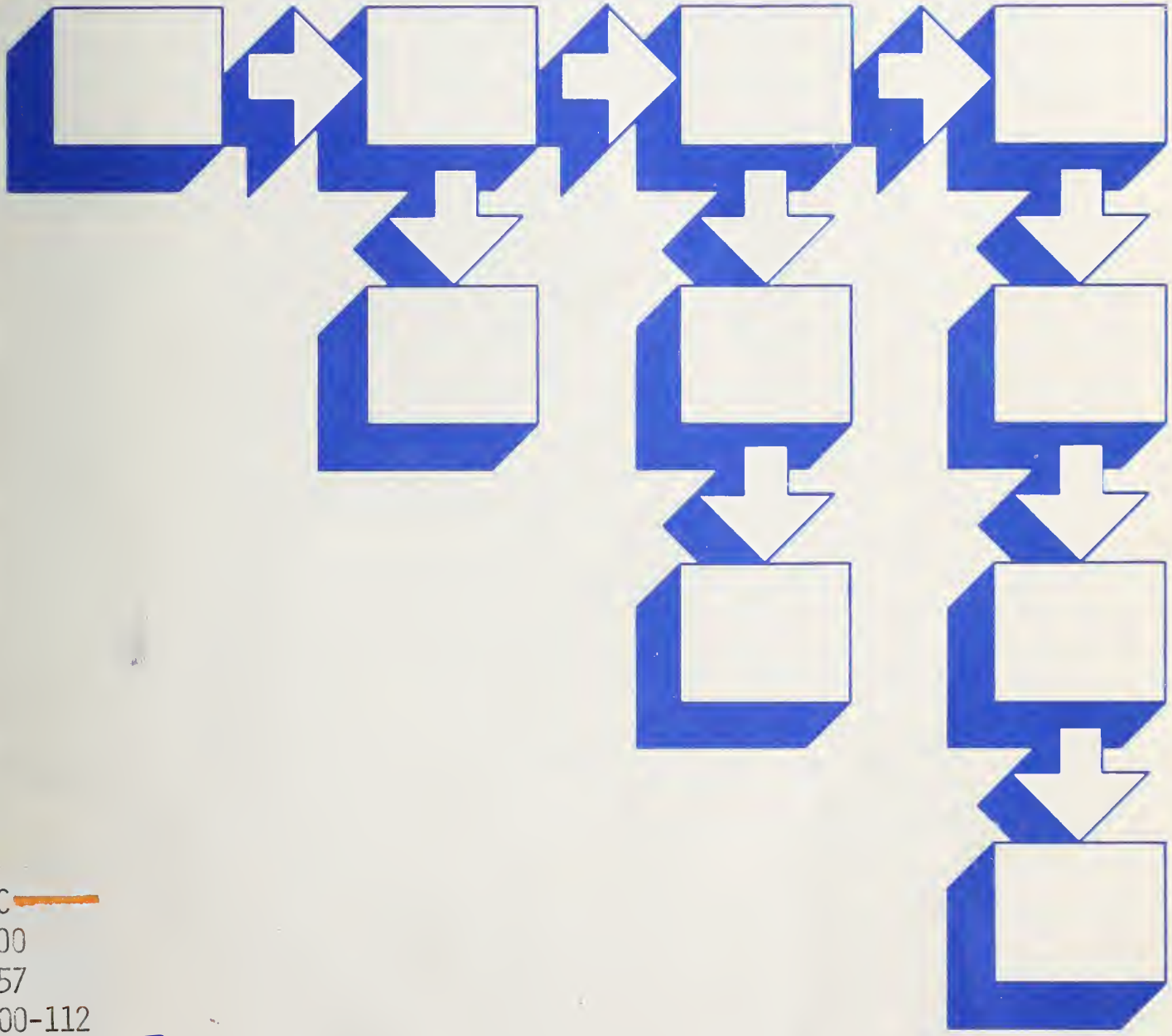
National Bureau
of Standards

Computer Science and Technology

NBS Special Publication 500-112

Selection of Microcomputer Systems



NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

THE NATIONAL MEASUREMENT LABORATORY provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities[2] — Radiation Research — Chemical Physics — Analytical Chemistry — Materials Science

THE NATIONAL ENGINEERING LABORATORY provides technology and technical services to the public and private sectors to address national needs and to solve national problems; conducts research in engineering and applied science in support of these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

Applied Mathematics — Electronics and Electrical Engineering[2] — Manufacturing Engineering — Building Technology — Fire Research — Chemical Engineering[2]

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following centers:

Programming Science and Technology — Computer Systems Engineering.

[1]Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.
[2]Some divisions within the center are located at Boulder, CO 80303.

Computer Science and Technology

NBS Special Publication 500-112

Selection of Microcomputer Systems

John Barkley
Dennis Gilbert
Al Hankinson

Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, DC 20234

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Bureau of Standards
Ernest Ambler, Director

Issued March 1984

Reports on Computer Science and Technology

The National Bureau of Standards has a special responsibility within the Federal Government for computer science and technology activities. The programs of the NBS Institute for Computer Sciences and Technology are designed to provide ADP standards, guidelines, and technical advisory services to improve the effectiveness of computer utilization in the Federal sector, and to perform appropriate research and development efforts as foundation for such activities and programs. This publication series will report these NBS efforts to the Federal computer community as well as to interested specialists in the academic and private sectors. Those wishing to receive notices of publications in this series should complete and return the form at the end of this publication.

Library of Congress Catalog Card Number: 84-601010
National Bureau of Standards Special Publication 500-112
Natl. Bur. Stand. (U.S.), Spec. Publ. 500-112, 31 pages (Mar. 1984)
CODEN: XNBSAV

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1984

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

Contents

EXECUTIVE SUMMARY

This document assists end-users in evaluating the utility of microcomputer systems. For those end-users who have determined a need for a microcomputer, this document provides assistance in choosing a system which will satisfy their requirements. While the document is oriented toward the end-user, ADP professionals should find the material useful. Similarly, while the document focuses on administrative/management applications, the concepts are suitable to other application environments.

The methodology advanced in this guide recommends that primary consideration be given to user application requirements and commercially available software. Emphasis is placed on finding the appropriate tool to address specific needs rather than first acquiring a tool and then searching for a problem that it solves. The recommended sequence consists of:

1. identifying requirements

2. identifying and evaluating alternative sources for application software

3. identifying and evaluating alternative sources for system software and hardware

4. identifying and evaluating alternative sources of support

The issues that need to be addressed include: a) the relationship of micro-based systems to central facilities, b) the configuration of systems to facilitate the sharing of resources, c) the acquisition of application software in a way that minimizes development and maintenance costs, d) the "packaging" of the technology for non-technical users, and e) the acquisition of systems in a way that eases migration to new technology.

The Appendix provides an additional basis for understanding microcomputer system selection. The types of administrative/management applications available are presented, and the features associated with data communications are discussed.

This document is introductory to a more comprehensive treatment of the subject of selecting microcomputer systems that is in preparation and will be available late in FY 1984. Information about that guidance document and other NBS microcomputer-related products and actvities can be obtained from the authors at:

NBS/ICST
B266 Technology Bldg
Washington, DC 20234
(301) 921-3485

CHAPTER 1

INTRODUCTION

This document is primarily intended to assist end-users who are faced with the tasks of evaluating the applicability of microcomputer systems technology to their needs, and selecting a system to meet those needs. Although the document focuses on end-users, the material should also be of use to computer professionals who are selecting microcomputer systems for use by an organization. While the information presented here is generally applicable across the full range of microcomputer applications, a primary focus is on issues which arise in an administrative/management environment. Our experience is that the use of microcomputers for administrative/management applications has the largest potential payoff for Federal agencies.

This document is limited in scope. A more comprehensive treatment of the subject is presently underway. While the material was specifically designed to help Federal agencies make better informed decisions in the selection of microcomputer systems, information presented may be useful for private organizations, and state and local government organizations.

The ready availability and adaptability of microcomputer systems, which are compact enough to easily fit on a desk or in a briefcase, will change the expectations, and the habits of users of information systems. The microcomputer system has advanced to the point where individuals can make effective use of information systems technology without being highly trained specialists in the technology. In addition, these systems are beginning to mimic capabilities of large mainframe computers of only a few years ago. It has been characteristic of the past that enhanced computational resources usually lead to attempts to take on new problems, as opposed to just solving a larger volume of the old problems.

The discussion above would lead one to expect the evolution of a whole new set of applications that were unthought of prior to the advent of microcomputer systems; and indeed, a new class of "spreadsheet" processing applications has already emerged. Spreadsheet processors allow end-users to develop, inexpensively and quickly, specialized display tables representing budgets, taxes, and other computational models. A key characteristic of these models is that changes in table values are almost instantly propagated to all

other dependent values. The concept underlying the spreadsheet processor is simple, but was not realized until microcomputer systems provided the low cost, fast response, and high bandwidth environment to make implementation feasible.

The spreadsheet application is just one of a growing list of applications that bring computing power within reach of end-users. This ready access to computing power offers the potential for both large and small organizations to significantly improve the productivity of their workforce as well as the quality of the products and services being provided.

There appears to be a tremendous amount of pressure on both individuals and organizations to get on the "microcomputer systems bandwagon" without fully exploring the issues involved. Inexperience in the use of this new technology increases the risks that organizational goals will not be adequately considered, and that selection decisions will be made by people who are not equipped by either training or experience to make such decisions. Mass media marketing tends to paint an overly optimistic picture of the capabilities of microcomputer systems and tends to obscure the issues that should be considered when making a system selection decision.

Chapter II of this document describes the process that we recommend for selecting a microcomputer system. Chapter III highlights some significant technical considerations associated with selecting a microcomputer system. The Appendix provides a more detailed technical discussion of microcomputer systems capabilities and applications.

CHAPTER 2

THE RECOMMENDED SELECTION PROCESS

A number of factors combine to make the process for the selection of microcomputers different from that of mainframes. Microcomputers will typically have associated with them:

- a shorter life cycle
- a lower unit cost
- a lower perceived risk
- a greater need for matching and integrating system components by the user
- a greater interest in individual computing by the user
- a greater overall control and responsibility on the part of the user for individual computing

Some factors contributing to these differences include:

- fast moving technology
- increased market place competition
- a low system cost
- evolving requirements, particularly for first time users
- difficulty and expense of modifying application software
- significant media coverage of microcomputers, the technology and the market place

Traditionally, the selection of mainframes has been associated with a focus on hardware. In contrast, the methodology advanced in this guide recommends deemphasizing hardware and giving primary consideration to user application requirements and commercially available software. Emphasis is placed on finding the appropriate

tool to address a specific need rather than first acquiring a tool and then searching for a problem that it solves. The recommended sequence consists of:

1. identifying requirements
2. identifying and evaluating alternative sources for application software
3. identifying and evaluating alternative sources for system software and hardware
4. identifying and evaluating alternative sources of support

It should be noted that while the steps are discussed as a series of sequential activities, in fact the process is more complicated and dynamic. Each step has implicit in it the task of insuring that the decisions made or alternatives identified up to that point are consistent and do not overly constrain the final choices. For example, the choice of a particular application package may dictate a specific operating system which decreases rather than increases the system's flexibility for expansion or enhancement. In such a case it may be advisable to reevaluate and modify requirements so as to still accomplish objectives, but yet remove the undesired constraints on future actions. In that light, the steps of the recommended selection process are discussed below.

2.1 IDENTIFY REQUIREMENTS

Clearly, the process of requirements identification does not take place in a vacuum. Although we would like to initially state what we want independent of available resources, in actuality that is not exactly the case. In fact, we begin to frame such concepts in terms of what currently exists or the expectation we have of what will be available shortly. Some sources of information about the capabilities of available software and hardware include:

- o microcomputer and information systems periodicals, journals and newspapers
- o vendor literature
- o electronic bulletin boards
- o technology forecasts
- o local computer stores

(See NBS Special Publication 500-102, Microcomputers: A Review of Federal Agency Experiences, page 7, for a description of the Institute for Computer Sciences and Technology (ICST) Microcomputer Electronic Information Exchange which contains pointers to other sources of

related information.)

One step in identifying requirements is to recognize the generic class of applications that the system is intended to support. Typical classes include:

- o administrative/management
- o scientific computation
- o software development

Our experience to date suggests that users should select a system that operates within the boundaries of or is primarily directed toward a single class. Each class provides the user with a wide and growing variety of functions that can be performed. Among the responsibilities of the selector is the choosing of the desired functions and prioritizing them. Although it is not possible to place quantitative figures on the relative importance of each category of application, within Federal agencies, that of administrative/management appears to be of particular significance. Some typical administrative/management functions include:

- o document preparation
- o financial analysis
- o personnel management
- o data management
- o budget preparation
- o briefing material presentation
- o forecasting

Also involved in this step is the specification of any limitations or constraints imposed on the choice of solutions. These might include such things as:

- o agency policy and/or guidance
- o Federal regulations
- o budget limitations
- o compatibility with installed systems
- o familiarity of staff with the systems under consideration

- o availability of support structures both within and external to the organization
- o availability of an off-the-shelf solution

Unless the system to be selected is to be used exclusively as a general learning tool, it will be necessary to define the specific functional capabilities that it needs to support, when those capabilities need to be available, and the priority or importance of each functional requirement. The last is important because it is possible that one system may not be capable of simultaneously satisfying all requirements given the imposed constraints. Related to functional capabilities are the performance and capacity requirements of the system to be selected. These too must be identified and prioritized.

One distinction among types of off-the-shelf application software is that between those that perform a specific application function (eg, inventory control, project scheduling, education, bill of materials) vs those that provide the user with a general tool that can be tailored to the specific problem. Word processing, spread sheet, database, graphics are examples of this general tool category. It is recommended that for administrative/management applications that systems be required to provide as a minimum a workable set of these latter capabilities. Further, it is recommended that there be a requirement for some level of integration among them.

An area of requirement that should be considered relates to how the user interacts or interfaces with the system and the desired degree of user friendliness. Factors such as previous user training and experience and the sophistication and complexity of the system to be selected should be considered.

Yet another area of requirement to be specified is the degree to which the system to be selected must interface and communicate with other work stations and mainframes and the method(s) for accomplishing this. The extent to which the full range of these interactions can be anticipated and specified can impact the extent to which costly later adjustments are necessitated or avoided.

2.2 IDENTIFY AND EVALUATE ALTERNATIVE SOURCES FOR APPLICATION SOFTWARE

This step consists of seeing what application software exists to satisfy requirements and choosing from among the alternatives within the imposed limitations and constraints. In identifying alternatives it is important to make some distinctions among types of off-the-shelf packages. One distinction is between commercial vs public domain software. On the obvious level public domain software has the "apparent" cost advantage. While some public domain software is extremely good, especially in the area of communications, it is frequently plagued by no or poor documentation and by lack of a

maintenance and support structure behind it.

Some agencies do make extensive use of such software with a central support group performing the appropriate tailoring, documenting, distributing, and consulting. A recent development has been the use of company (and public) libraries to distribute diskettes of public domain software much the same as books are loaned to users. A large inventory of administrative/management software of commercial and public domain software is available. The inventory is increasing practically daily. However, the quality, utility, documentation, user friendliness, and training aids associated with this type of software vary considerably. Therefore, while the use of public domain software may be viable, a decision to go that route should be made with an appreciation of the potential problems and the non-apparent costs.

Decisions about microcomputers will necessarily be in the absence of complete knowledge. Therefore, questions that need to be addressed include:

- what level of information is necessary to operate with some degree of confidence - short of devoting an inordinate amount of time and energy?
- to what extent is expert assistance/opinion necessary and/or advisable?

Equally important to the user as the selection of a software product may be the selection of a software vendor. A reputable vendor (developer and distributor) increases the likelihood of:

- responsive service including the availability of knowledgeable technical staff
- a tested, documented product
- the availability and honoring of appropriate warrantees/guarantees
- upward and downward compatibility within a vendor's line
- continued product enhancement

A vendor's ability to provide these types of support should be an important consideration in the vendor selection process. Unfortunately, it is extremely difficult, if not impossible, to apply quantitative measures to this process. In the absence of such metrics, reliance on one's own intuitive and professional judgements and those of people whose opinions are respected may be necessary. (Interestingly, in the consumer market, a sometimes identified decision criterion in buying a system is having a friend who has and recommends a particular system and who can provide support, encouragement, and hand-holding.)

In evaluating specific application software and specific vendors it is important to be aware of whether what is being considered represents a "mainstream" in terms of both the technology and the marketplace. Dealing with mainstream products that have a wide customer base and constituency puts the users in a more flexible position to have access to sources of support, a greater range and depth of available products, a larger pool of knowledgeable technical and user personnel, a stronger position to exert leverage on the vendors to be responsive to product bugs and shortcomings.

Another advantage of dealing in the mainstream is that the marketplace is more likely to be responsive to that environment. This frequently translates into the availability of a variety of related products that support, enhance or complement the primary product.

Another consideration concerns the user selecting application software to address more than one function (e.g., spreadsheet and graphics and database). In such a situation, where practical, it may be advantageous to obtain that software from a single vendor. Families of software packages and integrated environments (see related discussion in the Appendix) are being offered by an increasing number of vendors.

Integrated software packages offer two advantages. It is easier to share data between the functional programs, and the functional programs have similar user interfaces. Consequently, the operational detail that the user must remember is minimized. On the other hand, the functional programs in an integrated package, evaluated on an individual basis, may not have the features or performance of similar programs, where each is obtained from a different vendor.

2.3 IDENTIFY AND EVALUATE ALTERNATIVE SOURCES FOR OPERATING SYSTEM SOFTWARE AND HARDWARE

Of prime importance in this step is that the selected system software and hardware support the full range of application software identified in the previous step. It is frequently the case that a particular application software package will go through an evolution of improvements that take the form of successive versions. It is important that the system software and hardware being considered continue to support the latest versions as they become available. (For example, a major vendor in the home computer market supports an older version of a popular spreadsheet package, but not the enhanced versions available on other systems.)

Many of the considerations used for selecting application software and an application software vendor are also appropriate in the selection of system software and hardware. Alternatives which increase rather than decrease flexibility, which conform to de facto standards, which put users in the mainstream, and which permit dealing with a responsive and viable vendor are favored. Application packages which force a marked variance from the perceived mainstream should be carefully reexamined and the tradeoffs reassessed.

This is especially important in this period of extremely rapid change where a time frame of a little as six months to a year may bring new products that can make previously acceptable ones less desirable when compared to the new offerings. A user staying in the mainstream of system software and hardware increases the likelihood that new offerings will be available with only limited requirements for system enhancements.

In attempting to find a system that supports a particular application or set of applications, the potential user must be extremely aware of the specific requirements of the system software and hardware. The application may require a particular operating system version. It may also require some minimum capacities - e.g. random access memory (RAM), number of disk drives, amount of disk storage, density of storage media, size of printer carriage, monitor type and display size. It may also require additional components - e.g. a particular board for communications or graphics or color. The absence of this level of detail may result in not being able to utilize the full capabilities of a particular application package.

In evaluating the choices of operating systems it is important to note the trend of a number of vendors to provide an "operating environment." In such an environment the operating system may be relatively transparent to both users and application developers. The environment is typically implemented in a high level, widely transportable language, such as C. Such an environment may provide the user with some of the advantages of leveraged learning, flexibility, and mainstreaming previously discussed.

2.4 IDENTIFY AND EVALUATE ALTERNATIVE SOURCES FOR SYSTEM SUPPORT

Support refers to the collection of activities necessary to help users access the selected systems, correct problems, learn and effectively use the systems, and evaluate alternative approaches. Included in this category are maintenance, training, documentation, demonstration centers, and package customization.

It is not necessary that support for the selected systems be obtained from the same vendors. However, it is advisable, but not essential, that the organization provide coordination of various support activities so that users will both know what support is available and how to obtain it. The coordination is particularly important when a variety of in-house and outside support is being obtained.

Although certain types of support can be provided with little, if any, knowledge of the users environment (for example in the case of hardware repairs), many types of support require such knowledge. An example of the latter is the determination of the applicability of a particular application package that must interface other organization resources.

A study conducted by Arthur Young for the Department of Defense identified thirteen different categories of support. These included:

- o long range planning
- o requirements analysis
- o hardware selection
- o software package selection
- o procurement negotiation
- o application system development
- o installation
- o training
- o operations
- o maintenance

A recent review of Federal agency microcomputer experience performed by ICST, Microcomputers: A Review of Federal Agency Experiences, NBS Special Pub 500-102, found many of the interviewed agencies providing a subset of the full range of support, with none of the interviewed agencies providing all. A centralized microcomputer support group appeared to be the most commonly observed model.

CHAPTER 3

TECHNICAL CONSIDERATIONS

This section highlights several significant technical considerations that should be factored into the decision to select a microcomputer system. The technical considerations are presented as issues/questions and the ensuing discussion attempts to answer the questions. There was no attempt to be exhaustive in the coverage to technical issues. The particular issues presented were selected because they are generic in nature and because we feel that the discussion of these issues brings out those factors that are most important to consider when selecting a microcomputer system.

3.1 WHEN SHOULD MICROCOMPUTER SYSTEMS BE CONSIDERED AS ALTERNATIVES AND/OR ADJUNCTS TO CENTRAL FACILITIES?

Ideally microcomputer systems should be viewed in the context of an organization's overall information resources. Unfortunately, we have found very few examples in which this is the case. Some of the key reasons include:

- the difficulties of establishing and maintaining an effective program for managing information resources
- the relative immaturity of the organization's experience with the use of microcomputer systems as compared with the experience in the use of conventional technologies
- the revolutionary pace in which information technology is currently changing and is expected to continue to change over the next few years

Because microcomputer systems have not been fully integrated as part of an organization's information resources, these systems are most often used as automated tools to assist individual workers in processing information on an ad hoc basis to improve productivity and to enhance personal job performance. This is in marked contrast to conventional information systems technology which is primarily used to support organizational rather than personal job functions.

The notion of "personal computing" is very much evident in the present day microcomputer systems. These systems are most often configured as single-user, multi-function workstations designed to support applications in areas such as administration and management, science and engineering, and software development. Although multi-user systems are beginning to gain acceptance, single-user systems dominate the marketplace and are expected to maintain that dominance for some time.

There are no hard and fast rules which dictate when microcomputer systems should be used. There are, however, some experienced- based guidelines that are useful in identifying situations in which microcomputers should be strongly considered. These include situations in which:

- there is a need to facilitate applications that are highly interactive and that have a large amount of terminal I/O.
- the organization is confronted with a large applications development backlog.
- there is a need for more end-user involvement and control of the operational environment.
- there is need to reduce the lead time for implementing an application.
- an organization is considering alternative ways for dealing with poorly structured, rapidly changing applications that serve individual as opposed to organizational, job performance needs.

There are also situations in which microcomputers should be approached with extreme caution. These include situations in which:

- there is a strong requirement for data sharing.
- application needs require the development of custom software.
- user support requirements have not been identified and provided.
- there are stringent security requirements.
- the applications are critical to the mission of the organization.

3.2 HOW SHOULD MICROCOMPUTER SYSTEMS BE CONFIGURED TO ENHANCE THE SHARING OF DATA AND THE SHARING OF EXPENSIVE PERIPHERALS?

There are two issues regarding data and resource sharing with microcomputer systems. The first issue relates to sharing data and resources among functions within a single multi-functional system. The key concern here is the degree of compatibility among the various functions provided by the system. The second issue relates to data and resource sharing among a group of systems serving a multi-user environment. The key concern here is the degree of compatibility among the various systems. These two issues will be discussed in the paragraphs which follow.

3.2.1 Intra-System Data And Resource Sharing

The ability to expand functionality is one of the most important characteristics of microcomputer systems. Expanded functionality can be achieved by both software and hardware methods. The method recommended for achieving expanded functionality is via software. This can be accomplished simply by obtaining software packages that provide the desired functions. Problems typically arise when the software is developed as independent, stand-alone packages that are not designed to operate together. The key problems are:

- o inability to share data among the various programs
- o lack of a common user interface among the various programs

There is a growing trend among commercial vendors supplying software for administrative/management applications to integrate mulitiple functions within a single program or family of programs. These vendors combine commonly used functions into an integrated package having a consistent user interface and with the capability to use the output of any one function as input to any other function. Typical functions include:

- o spreadsheet processing
- o word processing
- o business graphics
- o database management
- o communications (primarily terminal emulation)

The single integrated program, as a rule, allows for easier switching from function-to-function than does the family of compatible programs. On the other hand the family of compatible programs usually provides a more extensive set of features than does the single integrated program.

Expanding functionality via hardware is achieved by inserting printed circuit boards that provide those functions into connection slots on the internal bus. The following types of problems are typically encountered when using this approach:

- different printed circuit boards require the same connection slot on the internal bus. This of course means that the functions provided by those different boards cannot coexist.
- lack of software support for functions provided in the printed circuit boards.
- some new printed circuit boards require additional power and cooling.
- ability to add functions is constrained by a limited number of expansion slots.

Because of the level of technical expertise required, end-users should proceed with extreme caution in attempting to expand the functionality of their systems by hardware methods. It should be avoided whenever practical; if it cannot be avoided, expert technical assistance should be obtained.

3.2.2 Inter-systems Data And Resource Sharing

Some organizations may want to interconnect their microcomputer systems. In addition, there is usually the need for microcomputer systems to be connected to the organizations' central computing facility. In scientific/engineering applications this interface would be primarily used to provide access to a high-speed computational capability; for applications in software development this interface would be important for testing and integrating elements of a system under development; and in administrative/management applications, this interface would provide access to a shared corporate database.

In those situations in which there is a need for data and other resource sharing among microcomputer systems, or between microcomputer systems and a central computing facility, a few relatively simple alternatives should be examined before pursuing the potentially expensive and technically risky effort of acquiring a network. These are:

- interchanging diskettes by using format conversion software
- transfering files via a direct communications link
- utilizing "shared resource" systems

Manually exchanging diskettes by using format conversion utilities can be an effective method for data and resource sharing. Incompatibilities, which cannot be solved by software utilities, can occur because of differences in diskette drive design and the physical characteristics of the diskettes. Software utilities can solve incompatabilities based on the soft-sectoring of the diskette or the logical structure of the files.

The next approach to data and resource sharing that should be examined is electronically transmitting files via direct cable connection between I/O ports (typically the RS 232C port) on the systems. There are commercial and public domain products which support this method of file transfer. The limiting factor in this approach is that the systems involved must be located relatively close (typically within fifty feet) to each other. A variant to this approach that overcomes this distance limitation involves the use of modems and telecommunication lines to establish the data path for file transfers.

Since most organizations already have terminal access to their central computing facility using direct wire or telephone, data sharing between a microcomputer and the central computer can be accomplished over the existing terminal communication links. Microcomputer to microcomputer data sharing can be accomplished by using the central computer as the communication link. In this approach, data from the sending microcomputer system is placed on the mainframe. The receiving microcomputer accesses the mainframe to obtain the data. There are two advantages to this approach. The mainframe is presumably always up. Thus, the sending microcomputer system may transmit at any time, and need not depend on the receiving microcomputer being on. Secondly, two microcomputers may exchange data even if they are unable to exchange physical media.

"Shared resource" systems are multi-user systems in which one or more of the system components are shared among the users. The salient characteristics that distinguish among these systems are (1) the system resources that are being shared, and (2) the degree of autonomy that exists among the users. In some systems, only a few peripherals such as a winchester disk or printer are shared, while in others all of the system resources (including the processor) are shared among the users. From a user's perspective, the key problems with the shared logic approach are:

- o users must give up some measure of control over their individual operating environments
- o degradation is likely to occur in performance due to the need to schedule access to shared resources

A network (i.e., a collection of computer systems interconnected by communications facilities to allow multi-user access to shared resources) approach to data and resource sharing should be considered only after careful analysis of requirements. The advantages of this approach are:

- high performance, reliable access to shared data and resources
- users can have the benefits of a multi-user environment without surrendering autonomy of their individual operations

The process for selecting a specific network technology and topology is very complex and requires expert technical assistance. Equally important is the fact that operating and maintaining a network is a difficult and highly technical activity. Such an effort requires assignment of appropriate staff and other support resources. NBS Special Publication 500-96 "The Selection of Local Area Computer Networks" provides guidance on analyzing requirements and selecting the appropriate network to meet those requirements. That publication should be consulted before making a decision to proceed acquire a network.

3.3 HOW SHOULD APPLICATIONS SOFTWARE BE ACQUIRED IN ORDER TO MINIMIZE DEVELOPMENT AND MAINTENANCE COSTS?

Microcomputer systems have contributed to the growing trend toward end-user computing. Their low price, ease of use, and quick responsiveness enable many users to solve their own computing problems, often bypassing the traditional DP organization. The potential benefits of end-user computing are substantial and are well recognized. The costs, however, can be equally substantial but are not as well recognized. The risks that the cost of end-user computing will negate the benefits are considerably increased in those situations in which end-users write their own application programs. End-users rarely have the skills required to produce software comparable to that produced by an experienced professional.

It is for these reasons that we strongly recommend that users of microcomputer systems buy, rather than build, their applications software. Another reason for the recommendation to buy rather than build is the large number of relatively inexpensive commercially available application packages, particularly packages which support administrative/management functions. Packaged software seldom meets all of the requirements of a particular application. Users should therefore be prepared to make reasonable compromises and must carefully evaluate the need for a customizing effort.

In those situations in which it is determined that a customized application is required, end-users should obtain the advice and assistance of individuals with expertise and experience in software development. Although the software development environment provided by microcomputer systems is not yet comparable to that provided by mainframes, there are a number of application development tools which have been used successfully in the environment of microcomputer systems. The tools which have been shown to be particularly useful are spreadsheet processors and database management packages. Spreadsheet processors are being used primarily for financial

modelling and budgeting while database management packages are being used for the broad spectrum of database query and reporting applications.

3.4 HOW SHOULD THIS TECHNOLOGY BE "PACKAGED" TO MEET THE NEEDS OF END-USERS?

Many of the new systems are being touted for their "user-friendly" features. Typically, this means that (1) it is relatively easy to learn to use the basic features provided by the system, and (2) once a user has learned to use a feature in one part of the system (e.g., text editing in word processing), that learning is transferable to other parts of the system (e.g., text editing in database management). One of the advantages of integrated packages is that they typically provide a more "user-friendly" environment than does a collection of packages developed independent of each other.

This notion of "user-friendly" does not mean that the end-user can operate independent of technical support provided by individuals with expertise in the particular system being used. There is still a need for specialized training and support for situations ranging from insuring that peripherals (e.g., printers) are properly connected, to evaluating alternative strategies for dealing with the problems that invariably arise when using an automated system. Therefore, regardless of the characteristics of a particular microcomputer system, the fundamental issues for the end-user are:

- what kind of training and support is required
- where is the training and support available

Training and support are inextricably interrelated. The kind of training required is, to a large degree, a direct function of the kind of support that is available. The basic functions involved in managing, operating and maintaining a microcomputer system are essentially the same as those associated with larger systems. These include:

- making sure that the system is configured properly
- maintaining a proper operating environment
- protecting the integrity of the system and data
- maintaining supplies
- operating the system
- evaluating system performance (including error detection and correction)

Someone must assume responsibility for these basic functions. Since the typical microcomputer system operates in a completely stand-alone environment, it may not be practical to assign many of these functions (e.g., operating the system, maintaining a proper operating environment, etc.) to a central support staff. The training should be designed to address those particular functions expected to be performed by the end-user.

3.5 HOW SHOULD SYSTEMS BE ACQUIRED TO FACILITATE ORDERLY MIGRATION TO NEW TECHNOLOGY?

The rapid pace at which new technology is being introduced gives rise to concern about becoming "locked-in" to obsolete systems. Users should examine system selection decisions in light of the need to minimize the risks associated with obsolescence.

One of the best ways for a user to avoid becoming locked-in to obsolete systems is to select products that have a large user community. Vendors with products having a large user community are motivated to provide a migration path to new technology. Users should examine products to determine how well those products are being accepted in the commercial marketplace, and how well the vendor supports his products. Users should be especially careful about products offering unique features to insure that those features don't isolate that product to a narrow portion of the market. Users whose requirements can be satisfied by products in the mainstream of the marketplace will minimize the risks associated with obsolescence.

Users should also be cautious about selecting a product in the later stage of its life-cycle. There is usually a trade-off between selecting a product in the early stages of its life-cycle and selecting a product in a more mature stage of its life-cycle. Selecting a product too early runs the risk of having to deal with problems typically associated with immature systems. Selecting a product too late runs the risk of early obsolescence. An assessment of the technology underlying the product should be a key consideration in making the trade-off. A well established product based on new technology is the optimal choice. A new product base on old technology should be approached with caution.

APPENDIX

CHARACTERISTICS OF MICROCOMPUTER SYSTEMS

A.1 INTRODUCTION

This Appendix provides a more detailed technical overview of the features and capabilities of microcomputer systems. The emphasis is on the application areas of administration/management and communications.

Microcomputer systems are available with many diverse applications software packages which are human engineered for both the experienced and the inexperienced computer user. This software explosion has been caused by two factors: the declining cost of the hardware, and the ever increasing numbers of end users who own hardware, and are demanding friendly, flexible software. The larger software market means that huge revenues can be generated by selling many copies of a successful software package. This potential return on investment has attracted many talented, creative people to the production of software.

The result has been the creation of software packages that are:

- Original in concept

  Since many software packages have little or no resemblance in concept to the packages which have been available for minicomputers or mainframes, even the experienced computer user often gains new perspectives. Not only do microcomputer systems solve new problems, they also provide solutions to the old problems in new and original ways.

- Highly interactive

  Systems are designed to take advantage of higher bandwidth interactive techniques such as function keys, "mouse" devices, and trackballs.

- Easy to use

The system can be used with minimal reference to a manual. Help at both a novice and expert level is often available on-line. In addition, the systems try to minimize the possibility of data loss caused by user error.

- Easy to learn

  The documentation for most packages includes not only the traditional reference manual, but also tutorial materials for the naive user. In some cases, tutorials are in the form of computer aided instruction.

Two examples of software with these characteristics are the spreadsheet processor and the integrated package.

The spreadsheet processor was initially conceived to automate some of the accounting calculations performed on large accounting spreadsheets. The basic concept of the spreadsheet processor is that instead of just being able to enter a number in a spreadsheet cell, as in the case with a paper spreadsheet, one can enter a formula which represents the value of the number as a function of other cells. When viewed on the display, the value of the formula is shown, and if a value of a cell is changed, then the numbers shown on the display, which are a function of the cell changed, all change their values instantaneously.

Since its introduction, the spreadsheet processor has been applied to many other tasks beyond those associated with an accounting spreadsheet. Such applications include financial modeling, the preparation of tables to be included in documents produced by word processors, and the maintainence of small databases. The spreadsheet processor has its own form of "programming language" unlike traditional programming languages. Using a spreadsheet processor is a learning experience for all users regardless of their backgrounds. The spreadsheet processor has become so successful that it is now a required part of any administrative/management application.

Integrated packages are software packages which combine the functionality of many traditionally separate processors into a single processor with a single user interface. Before the widespread availability of microcomputer systems, processors such as word processors, database management systems, etc., often produced by separate vendors, interacted with the user according to their own philosophy of human-machine interfacing. These packages were "integrated" by using the computer operating system which may have been produced by yet another vendor. As a result, the user interface was often inconsistent, confusing and inefficient. It was often impossible to exchange data between the processors, such as, using a report generated by a database management system as part of a document being prepared by the word processor.

The integrated package, produced by a single vendor, is one of the solutions to these problems. The concentration on human engineering and inter-function data portability in the design of integrated packages has resulted in new ways of looking at the

traditional functions, and in widespread use of interactive techniques beyond the teletype keyboard.

For example, spreadsheet processors may be combined with relational database systems by considering a record as a row in the spreadsheet. The contents of a cell in a spreadsheet can be treated as a document to which a word processor is applied. A rectangular area of a spreadsheet can be a table from which a bar graph or pie chart can be drawn. To this graph, special lettering or pictures may be added by electronic "drawing." These operations are no longer performed solely by typing commands on a keyboard. Commands to the integrated environment are often entered through a special interactive device such as a "mouse."

Microcomputer systems are being used to solve problems in almost every application area. Among the most common application areas of microcomputers are administrative/management and communications.

A.2 ADMINISTRATIVE/MANAGEMENT APPLICATIONS

Administrative/management (or office automation) applications can be grouped into the following catagories:

- Word processing

  Word processing was the first office activity to be automated, and is the most prevalent. Word processors were also the first integrated packages in that, in addition to text editing and formatting functions, most word processors include the ability to manage small databases such as mailing lists.

- Database management

  Microcomputer systems support the three basic types of data management systems, hierarchical, network, and relational. Relational or relational-like database systems are the most common implementation. These are general purpose information management systems capable of most database applications and limited only by the size of mass storage.

- Spreadsheet processors

  As described earlier, this electronic calculator has become a necessary part of every office system. For many integrated packages, the spreadsheet processor is the base on which each of the other processors (i.e. word processor, database management system, etc.) is built.

- Business graphics and graphic arts

These packages effortlessly produce charts and graphs, such as bar graphs and pie charts, suitable in an administrative/management environment. Some also provide the capability of adding customized artwork to the graphs, for example, a corporate symbol or stylized lettering.

- Calendar managers

  These packages vary widely in the extent of their capability. At the minimum, they provide an electronic desktop calendar on which appointments can be recorded. Some calendar packages display messages when it is time for an appointment. Some packages, when available on systems which can communicate, will permit a manager to schedule a meeting through the system. When given the participants in the meeting, it will interact with the manager and access the calendars of the participants to arrange a time when all are available, and then, send a message to each participant and mark their calendars.

- Electronic mail

  This capability includes both mail between users of a multi-user system, and mail between between users of different systems. Mail is an application of the more general concept of data communications which is discussed in a subsequent section.

- Voice processing

  Some microcomputer systems provide the capability of interfacing to a voice telephone system. The microcomputer is able to do such things as answer the phone and receive dictation, place calls and send voice messages, and mix voice and digital data in data files which may be used as messages in electronic mail.

Software packages for these application catagories are available in the public domain and from several vendors. As was mentioned above, integrated packages which combine several application categories into a single program with a consistent user interface are also available. Users should be aware of several characteristics of these software systems.

Since it is usually not possible to find a single package which will perform all the desired functions, it is necessary for users to do their own "integration" of systems from different vendors. Most packages are able to input and output sequential files, consisting solely of ASCII text, thereby providing the means of transferring data from one package to another. Some formatting changes to these files may be required and this can usually be accomplished by a text editor or a small formatting program implemented by the user.

A microcomputer software package is usually available to run on more than one piece of hardware. A serious problem arises when there is no single piece of hardware and/or operating system on which the needed software packages will run. In the case where there is a single hardware system available, but each package requires a different operating system on that hardware, the use of files on mass storage may still be a solution. However, this is unlikely since most operating systems use different mass storage formats. The only solution may be to have more than one microcomputer system to provide the functions needed. Data transfer between systems is accomplished either by direct communications between the systems or by each system communicating with a mainframe.

Since many software packages are truly original in concept, it is usually not immediately obvious that a particular software package can meet the need. In order to make this determination, the user is required to become familiar with the software under consideration. If this is not done, the user may miss the opportunity to have access to systems which do the required job in a comprehensive,satisfying and efficient manner, once the initial investment in learning has been made. The user should study the manuals and tutorials, consult user groups, and spend a few hours using the system.

Not only should a software package be viewed in terms of whether it performs the desired functions, but the manner in which the functions are performed should also be considered. In using any microcomputer system, certain sequences of operations, such as transmitting data to a mainframe, will need to be repeated on a regular basis. One of the common problems with software packages, particularly integrated packages, is that sequences of operations can be performed only in an interactive manner. This may surprise the experienced computer user who is familiar with systems capable of automating sequences of operations by means of command procedures in order to minimize end-user activity. The ability of a software package to be programmed to automatically perform sequences of operations should be carefully considered.

Because microcomputer software packages are designed to be friendly, naive users do not remain naive for long. They quickly learn the environment that the system provides, and demands new capabilities. The vendors are aware of this phenomenon. They know that the user population is constantly increasing its sophistication, and that the sophistication of their products must increase accordingly. Increasingly powerful and complex software is made possible by the continuing increase in the power of the hardware.

A.3 COMMUNICATIONS

A communications capability will always require a user system to be connected through some communications medium to the systems with which it is to communicate. This usually implies that the system will either be multi-user, connected to a network, or both. The network may be special purpose, such as a local area network, or a telephone

system, such as a private business exchange (PBX) or the public telephone system.

Among the problems to be solved in order for microcomputers to communicate to other microcomputers, minicomputers or mainframes, are:

- Flow control

  The transmitting system may send data at a different transmission speed than the receiving system is capable of accepting. For example, when data is transmitted from a microcomputer to a mainframe, the mainframe may become busy with higher priority tasks and be unable to accept data from the microcomputer, even though the microcomputer and mainframe may be sending and receiving at the same transmission speed. In order for communications to occur in these situations the sending and receiving systems must have some means of starting and stopping the transmission.

- Data integrity

  There should be some assurance, at the time of transfer, that the data which was transmitted is the data that was received.

- Transmission of binary data

  Many computer system communication links are designed for transmitting 7 bit ASCII data only. In order to transmit 8 bit binary data, the 8 bit data must be encoded into 7 bit data by the sender and subsequently decoded by the receiver.

- Connection initiation

  The previous problems address the issues of how communications proceed during the transmission of data. The problem of connection initiation deals with how the connection between two systems is established. Electronic mail, an application of communications, requires that one system be able to establish a connection to another system, transmit the message, and then break the connection. Most electronic mail systems are able to accomplish this task without any operator intervention.

Three available methods of implementing microcomputer data communications, in order of technical sophistication, are:

- Terminal emulation/file transfer systems

  These are the simplest, most common solutions to microcomputer communications. Since almost all mainframe and minicomputer systems permit the attachment of terminals, this class of communication system makes the microcomputer appear to the remote system as a terminal. Data transfer from the

microcomputer to the remote system is accomplished by the microcomputer reading a data file from its mass storage and sending the contents through the communications link as though an operator were typing the data on a terminal. Data transfer from the remote system to the microcomputer is accomplished by the microcomputer storing data from the remote system in memory and/or on mass storage. This type of communications system may engage in some type of flow control signalling with the remote system, or simply rely on a slow transmission speed. However, there is normally no data integrity checking, and no capability for the transmission of binary data. Connection and disconnection with the remote system, and data transfers are initiated by an operator on the microcomputer. Terminal emulation systems are available both in the public domain and commercially.

- Limited-function network systems

  This class of communication system can perform the functions of terminal emulation systems but, in addition, provides for some data integrity and binary data transmission. However, it still requires much operator intervention to initiate transmissions. It also requires that two systems be able to interact in a more sophisticated manner. With terminal emulation, the remote system communicated with what it saw as a terminal. Now, the remote system must know that it is interacting with another computer system according to an agreed upon set of rules or protocols. While terminal emulation systems arose from a need for microcomputers to communicate with mainframes, the limited-function network systems arose from a need for one microcomputer to communicate with another microcomputer. Since it can be more difficult to implement communications software on a large multi-user system than on a small microcomputer system, the limited-function network implementations have been available primarily for communications between microcomputers. Limited-function networks have been slow in becoming available for communications between microcomputers and mainframes. However, these implementations are becoming widely available in the public domain and commercially.

- Full-function network systems

  These systems provide complete, technologically sophisticated solutions to the communications problems mentioned at the beginning of this section. They are almost always acquired from a single vendor who provides all of the hardware and software. While some standards and conventions exist, full-function network systems, because of their complexity, have yet to reach the point in their development where an inexperienced user may obtain interchangeable parts of a network system from several vendors and/or in the public domain. The Institute for Computer Sciences and Technology within the National Bureau of Standards is contributing to

the development of international standards for network protocols that will lead to off-the-shelf network products existing in a multi-vendor environment.

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBS SP 500-112	2. Performing Organ. Report No.	3. Publication Date March 1984

4. TITLE AND SUBTITLE

Computer Science and Technology: Selection of Microcomputer Systems

5. AUTHOR(S)

John Barkley, Dennis Gilbert, Al Hankinson

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

Final

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

Same as item 6.

10. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number: 84-601010

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

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

This document is chiefly aimed at providing assistance to non-technical users in evaluating the applicability of microcomputer-based systems in addressing their needs and choosing appropriate systems. However, technical users providing related support to their organizations should also find the material useful. Similarly, while focussed for Federal users of administrative/management applications, there is general applicability to other environments.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Computers; computer evaluation; computer selection; computer use; microcomputer

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☒ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

31

15. Price

USCOMM-DC 6043-P80

ANNOUNCEMENT OF NEW PUBLICATIONS ON COMPUTER SCIENCE & TECHNOLOGY

Superintendent of Documents,
Government Printing Office,
Washington, DC 20402

Dear Sir:

Please add my name to the announcement list of new publications to be issued in the series: National Bureau of Standards Special Publication 500-.

Name _____

Company _____

Address _____

City _____ State _____ Zip Code _____

(Notification key N-503)

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH—The Journal of Research of the National Bureau of Standards reports NBS research and development in those disciplines of the physical and engineering sciences in which the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau's technical and scientific programs. As a special service to subscribers each issue contains complete citations to all recent Bureau publications in both NBS and non-NBS media. Issued six times a year. Annual subscription: domestic $18; foreign $22.50. Single copy, $5.50 domestic; $6.90 foreign.

NONPERIODICALS

Monographs—Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS under the authority of the National Standard Data Act (Public Law 90-396).

NOTE: The principal publication outlet for the foregoing data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The standards establish nationally recognized requirements for products, and provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers this program as a supplement to the activities of the private sector standardizing organizations.

Consumer Information Series—Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

Order the **above** *NBS publications from: Superintendent of Documents, Government Printing Office, Washington, DC 20402.*

Order the **following** *NBS publications—FIPS and NBSIR's—from the National Technical Information Service, Springfield, VA 22161.*

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. The Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NBS Interagency Reports (NBSIR)—A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service , Springfield, VA 22161, in paper copy or microfiche form.

U.S. Department of Commerce
National Bureau of Standards

Washington, D.C. 20234