U.S. Department of Transportation

μtps Microcomputers in transportation

GETTING STARTED IN MICROCOMPUTERS

SELECTED READINGS VOLUME 1

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16. Abstract

The Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) of the U.S. Department of Transportation provide training and technical assistance in the new and rapidly changing area of transportation application of microcomputers. These two agencies maintain up-to-date microcomputer references for transit and paratransit operators, transportation planners, and traffic engineers.

This document is one in a series of selected readings covering technical aspects of microcomputer equipment, software, data communications and other topics. Each volume of selected readings will focus on a single aspect. Thus far, these are:

Volume 1 "Getting Started in Microcomputers"

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PREFACE

It is difficult to know exactly where to look for information in the new and rapidly changing area of transportation applications of micro-computers. At UMTA and FHWA, we have tried to keep up with developments and to maintain up-to-date microcomputer references for transit operators, transportation planners and traffic engineers.

In our efforts to assess and keep abreast of developments in the micro-computer field, we develop technical reports on selected topics like hardware, communications, data base management, and others. We are also fortunate in occasionally discovering papers and articles by others that are particularly appropriate to transportation users of microcomputers.

This series of publications, "Selected Readings", is intended as a continuing source of readings selected for this audience. Each volume will focus on a limited subject area. Non-copyrighted material may be reproduced in full. Other material will be referenced with a source.

Another reference in this general series **is the "Software and Source Book"** (formerly titled "Information Source Book") which describes software available or under development for transportation planning, transit operation, para-transit and traffic engineering. If you don't have this software report, the latest update is available from either of the addresses below.

Finally, any donated (non-copyrighted) papers will be carefully reviewed for possible inclusion in future volumes. Papers should cover an area of very broad interest.

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Human Services

NUMBER 16 NOVEMBER 1980 MONOGRAPH SERIES

Microcomputer Applications in Human Service Agencies

This is a reprint of a publication by the U. S. Department of Health and Human Services. Much of the advice offered is as appropriate for small transit and transportation agencies contemplating microcomputers as it is for the intended audience.

James B. Taylor
with
Jacque Gibbons

PROJECT SHARE

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PROJECT SHARE has contracted for the preparation of a monograph series in order to survey the state of the knowledge or the state of the literature in selected subject areas of importance to the human services community. The monograph series provides an opportunity for authors to offer their views and opinions on these topics. It is the aim of Project SHARE to stimulate discussion through the publication of these monographs.

This monograph was prepared in fulfillment of a contract with Aspen Systems Corporation, publisher, as a contribution to the *Human Services Monograph Series*, Project SHARE, Department of Health and Human Services, Washington, DC. The views and opinions expressed in this monograph are entirely those of the author and are not necessarily those of DHHS or Aspen Systems Corporation.

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PREFACE

"FUTURE SHOCK," says Alvin Toffler, is the "stress and disorientation that we induce in individuals by subjecting them to too much change in too short a time."[1] Technology is the engine that drives changes in the modern world. Technology creates new capabilities, challenges old social beliefs and structures, disrupts and enriches our lives. Of all current technologies, none is more potent than the computer, and nowhere is the possibility of future shock more likely than with the microcomputer. Quite suddenly it has become possible for any small organization, any group or collective, to harness capabilities that, just 3 decades ago, were available only to the largest and mightiest institutions. This abrupt change has sometimes been called the "microcomputer revolution."

Of all organizations, those agencies that deal with human problems may have the most to gain from the microcomputer revolution. This monograph will show why and how this is so. It provides an introduction to the new microcomputer technology and explores how microcomputers can be used to meet human service needs.

In a sense this monograph is a primer designed to help the human service administrator or worker learn about microcomputers and about how to harness their capabilities. It should be helpful to those who wonder whether a microcomputer might meet their agency's needs or who need help in planning and implementing a microcomputer-based information system. The monograph is directed at the intelligent and interested reader, one who is familiar with human service work but unfamiliar with the black arts of electronics, systems analysis, or data processing. Simple examples are used throughout, and technical language is kept to a minimum.

In addition to being informative, this has yet another purpose. Many people in human service agencies view computers with a mixture of awe and fear, as if they were some pagan gods to be placated, served, and loathed. These feelings are not unreasonable given the fact that the big computers have too often been used in inhuman ways, coercing their servants and depersonalizing the service. But the microcomputers are something else again — humble tools best used in small settings. They are manageable and easily managed; servants, not masters. Hopefully this monograph will encourage the reader to view them — and use them — in this way.

In preparing this manuscript the authors were influenced by many people, especially those who attended their seminars on microcomputer applications or who engaged them as consultants. In working together on common tasks, the expert frequently gains as much as the student or consultee. The authors are grateful for discussions with David Nordland, University of Kansas Computer Center, and Steven Briggs, Johnson County Community Mental Health Center. Phyllis Nesbitt typed the manuscript and provided editorial assistance; the text was much improved as a result of her concern for clarity and style. Although the monograph itself was written by James Taylor, it owes much to a continuing dialogue with his colleague, Jacque Gibbons. The chapter on software is largely his — in content, if not in phrasing.

I. DOES YOUR AGENCY NEED A MICROCOMPUTER?

"Does your agency need a microcomputer?" Five years ago you could not have asked the question. Microcomputer technology barely existed then. Ten years from now you may not need to ask the question because microcomputers will be ubiquitous. Right now, however, microcomputers are new on the scene, and their implications are as novel and as far-reaching as was Henry Ford's Model T when it first appeared.

In the past, only the largest agencies could have their own computer systems. This is no longer true. Now most small and middle-size agencies can afford to own one or more microcomputers — small yet remarkably versatile machines capable of storing and reporting client data, keeping accounts, handling payrolls, carrying out complex statistical calculations, addressing envelopes, printing bills, and even doubling as word processing machines. The machines may be run by the average secretary who has had a few days of special training. This new technological breakthrough allows smaller agencies to assess their own operations in a way never before possible, and to have instant access to the kind of hard information useful for effective planning and program development.

This chapter has three focuses. First, it provides a brief, nontechnical introduction to the fast-moving world of microcomputer technology. Second, it surveys what the machines can do for social agencies. It includes a brief form that allows you to diagnose which needs the microcomputer might meet in your own agency. Third, it gets down to specific dollars and cents, so that estimates can be made of hardware costs.

Technical jargon is kept to the minimum. However, one cannot explain what computers do without using a few technical terms, and as you move closer to purchasing your own computer system, you will need to know more. So, for those readers who need to know, there are occasional paragraphs that *are* more technical: explaining RAM's and ROM's and bits and bytes, and other mysteries.

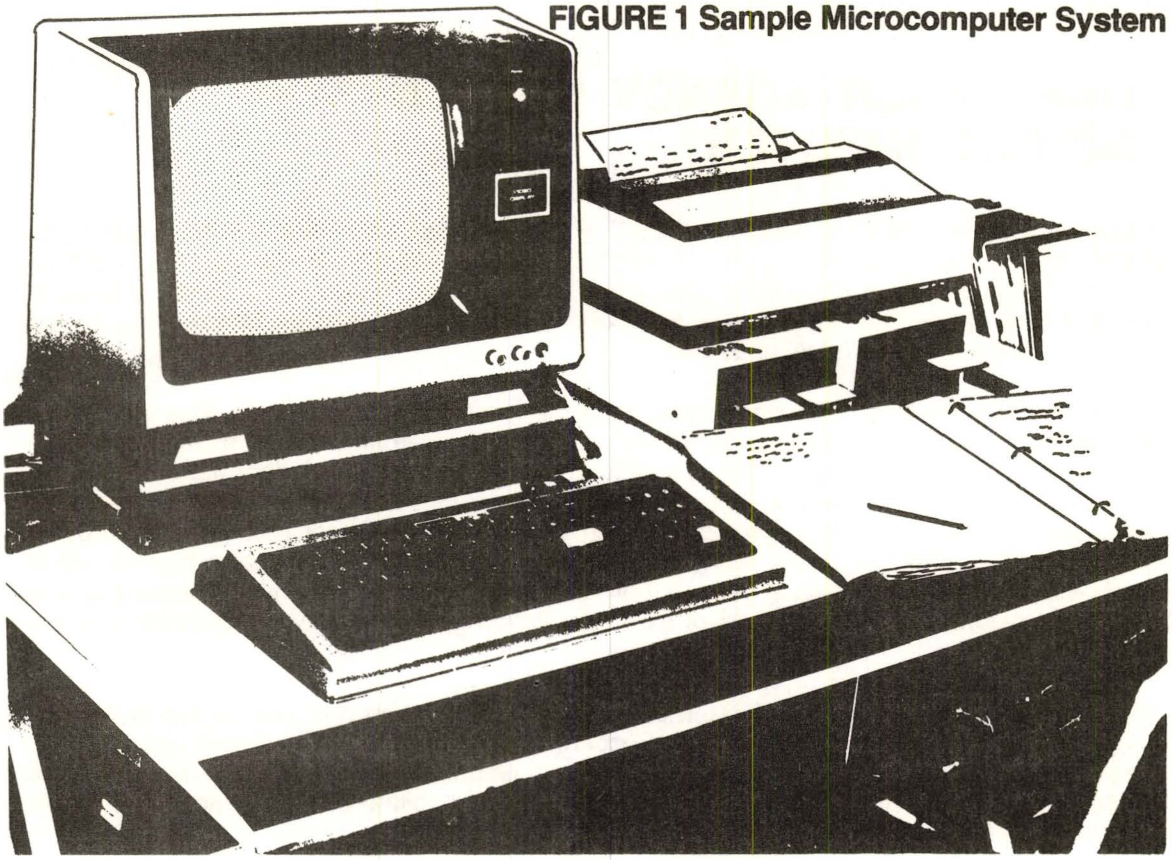
Hardware and Software

When most people think of computers, they envision a room filled with bulky, balky, blinking machines, ministered to by an exotic priesthood of white-jacketed specialists. The picture was true once, but no longer. Today's mass-produced microcomputer system is small and deceptively simple: it consists of a television screen; a small, self-contained keyboard that looks rather like a typewriter; and a portable cassette recorder. All the equipment fits on a typing table. The heart of the device lies in the keyboard unit that contains a silicone wafer about the size of a fingernail. On this "chip" is etched all the computer circuits and components that would have filled an entire room in the old vacuum tube days. The keyboard also contains other chips — called "memory" chips — that store a limited amount of data in easy access.

To this most basic system may be added a number of other devices — called "peripherals" in the jargon of the trade. These devices include printers, as well as various machines that make it possible to store much more data. Figure 1 illustrates a typical complex microcomputer system. Altogether, these machines constitute the "hardware" of the system. The computing power contained in such a system lends itself to a remarkable range of applications.

Using the computer, however, requires more than hardware; one also needs "software." Software is a term you will hear often, so a brief explanation is in order.

FIGURE 1 Sample Microcomputer System



Before the computer can do anything useful, it needs to be instructed. Instructions take the form of long lists which, if written in English, would look something like this:

1. Mr. Computer, set aside 100 spaces in your memory for variable "X."
2. Okay. Now start counting each case as you come to it.
3. Read the second variable for the case you just counted.
4. Read the fifth variable for the case you just counted.
5. Add together the second and fifth variables; call their sum "X."
6. Store "X" in memory, along with the case number so it can be identified later.
7. Check to see if you have done 100 cases yet. If not, repeat steps 2 through 6 again.
8. If you have done 100 cases, stop.

All of this just to add two numbers together for 100 cases! In real life, of course, the instructions are not written in English, but in one or another special computer "language" — usually a language called BASIC. The full list of instructions is called a "program," and programs are collectively referred to as "software."

Obviously, writing software is an arcane art, and if all the people who use computers had to write their own software, major software suppliers would long since have gone broke. You do not need to know how to write software in order to use the computer. You do, however, need to purchase already-written software, and it might have to be modified to suit your special needs. All this is discussed in more detail in later chapters.

Microcomputers Versus Minicomputers

You may be confused about the difference between the microcomputers and those other machines called "minicomputers." The terminology is confusing because "mini" and "micro" both mean "small." "Micro," however, means "exceptionally small." And that indeed is the difference. Microcomputers can store a more limited amount of information in their memory chips and tend to be somewhat slower, but they are a lot less expensive. They cannot easily handle very long numbers — a difference that is important in scientific work and in large businesses, but not in most agency applications. In essence, microcomputers can do almost everything minicomputers can do, but they do less of it and so are best fitted for the needs of small or medium-size agencies. Larger agencies would probably be better off with a minicomputer. Of course in this context the word "large" depends on the particular tasks that are demanded of the computer, but as a general rule of thumb, any agency with more than 40 full-time employees can be considered large.

The Microcomputer Revolution

When mass-produced microcomputers first appeared in 1977, they were marketed to hobbyists and to "computer freaks" who enjoyed tinkering with electronics or who wrote computer programs for relaxation. Often they were sold as game machines. But the manufacturers soon discovered another buyer, the small businessman. A number of firms now specialize in this market, and it is fast becoming well-established.

The mass-produced, mass-marketed microcomputer is the latest, most visible development of an incredibly fast-moving technology. Jones compares progress in the computer field to progress in the automobile industry:

> Electronic computers were originally designed in 1948. If Ford's technology had advanced at the same rate as computer technology, today's automobile would: weigh about five pounds, get 5,000 miles to the gallon, be the size of a small book yet somehow hold 20 passengers, be able to travel at close to the speed of light, and only cost about $3.00.[2] (p. 5)

With the new technology came new names and new products. Until very recently, major computer firms like IBM and Honeywell were conspicuously absent. The first of the preassembled microcomputers was marketed by Apple in 1976; Radio Shack introduced the TRS-80 in September 1977; Commodore brought out the PET a few months later. As this is being written, Radio Shack seems to be leading in sales. The company was astute enough to appeal early to the business as well as to the hobbyist market, and Radio Shack's 6,000 electronics stores now provide a national marketing and service network.

Hard on the heels of Apple, Radio Shack, and Commodore came a host of smaller companies that introduced new computers and new devices to hook into the machines. Still other companies began to market software of all kinds. Specialized microcomputer magazines started to appear — *Kilobaud, Personal Computing, Creative Computing* — their pages crowded with advertisements. With this proliferation of products came a proliferation of problems. A number of readers wrote to the computer magazines complaining of equipment malfunctions, lengthy delivery delays, and software that failed to work. The motto that governed this period was *caveat emptor* — let the buyer beware.

By 1980 much of the confusion had been sorted out. A few companies went bankrupt, and a few journals disappeared. However, some of the new hardware and software had developed a reputation for reliability and value. New user-oriented companies began to appear. These companies installed the hardware, provided the software, trained the user in its operation, and supplied maintenance under contract. Leasing arrangements became available for the more expensive microcomputer systems. Some companies began to specialize in particular applications — for example, systems were designed for businesses or for medical practices.

FIGURE 2 Sample Form for Diagnosing Your Agency's Computer Needs

Here are some chores that the computer can be set up to do routinely. Check those which would be helpful to your agency.

I. Client Information Systems Applications

___ 1. Generating summary reports—tables, graphs, charts
  ___ a. for Federal reporting
  ___ b. for State reporting
  ___ c. for other purposes (who) ________________________________
  ____

___ 2. Providing quick access to client background information or treatment data

___ 3. Tracking clients through multiple agencies or programs

II. Business System Applications

___ 4. Billing for services
  ___ a. to third-party payers
  ___ b. to client directly

___ 5. Figuring payroll

___ 6. Printing payroll checks

___ 7. Bookkeeping (ledger) operations

___ 8. Inventory operations

___ 9. Accounts payable operations

III. Word Processing Applications

___ 10. Producing marking lists and labels

___ 11. Producing personalized form letters

___ 12. Producing referral and summary letters

___ 13. Scheduling staff time

IV. Decision Support Applications

___ 14. Providing special information to help management in planning and budgeting

___ 15. Providing special information to be used for program evaluation or program monitoring

___ 16. Doing statistical computations—for example, finding means, standard deviations, correlations, test of significance, etc.

___ 17. Providing forecasts of future service and budget needs

V. Blue Sky Applications

___ 18. Administering and scoring ability tests or personality inventories

___ 19. Conducting assessment or screening interviews with clients

___ 20. Exchanging information with other agencies

___ 21. Doing bibliographic and other reference searches

In short, the 5-year growth of the microcomputer market has been phenomenal. Forecasters suspect that this is just the beginning, and that the impact of microprocessor technology will be at least as great as the impact of the mass-produced automobile or the jet airplane — and just as unpredictable. For example, microcomputer technology makes small, inexpensive robots practical. When such robots start to displace assembly line workers on a larger scale, who knows what the social results will be? More to our point, however, this new technology has profound implications for small and medium-size social agencies, making possible things that were never possible before. This brings us to the major issue of this chapter: What specifically can the new microcomputers do for your agency? And at what cost?

Diagnosing Your Needs and Costs

Perhaps the simplest approach is to examine the form shown in Figure 2, designed to help you diagnose your agency's needs. First check off those options that apply to your particular situation. What chores can the computer do for your agency? Now that you have checked off your potential needs, let's look at these applications in greater detail.

Client Information Systems

A typical human service agency collects vast amounts of information on the clients it serves — most of which gets buried in file drawers where it is largely unusable. The computer is capable of storing a great deal of information about clients either on tape or on special storage devices called discs. Once this data is stored, it becomes totally usable. In practice, storage on tape is not recommended except for very small agencies with very few clients; it simply takes too long to find the information you want. So this discussion focuses on discs.

Discs come in various sizes and are available to meet almost any conceivable need for data storage. Given the proper software, client information can be filed on a disc; the computer can search very quickly through client records; it can pull specific data for specific cases; it can aggregate and summarize client information; it can produce routine reports in a standard reporting format; and it can draw bar charts and other kinds of diagrams.

There is one catch, however. The computer can do these tasks only if most of the data is given to it as numbers, not as text. The average agency case folder is full of case descriptions, written out in words and sentences. But the computer is not very good at handling words or sentences. So code numbers have to be assigned to specific items of information, and these numbers must be entered into the computer. For example, Figure 3 shows a face sheet form set up so the client information can be fed into a computer.

The average agency devotes a great deal of time and effort to developing a workable client information system. Such systems do not just happen; they must be invented. The agency *must* consider the following questions:

- What do we really need to know about our clients?
- For what purposes?
- What kinds of data collection forms are workable?
- What kinds of analyses do we require?

This process of thinking through such matters is sometimes called "systems analysis." The term "headware" refers to its outcome. Chapters 2 and 3 discuss the headware tasks in more detail.

Costs? It depends on how much client information needs to be stored. Most agencies can meet their needs by storing their data on "floppy" discs, and the total machinery costs need not run over $4,500. This includes two "floppy disc drives" to read and record the data, a printer to print

FIGURE 3 Precoded Face Sheet: Confidential Information

CONFIDENTIAL CLIENT INFORMATION

2-7 Client No. ____________

13-40 Name: ____________ 97-102 Date: ____________ Mo. Day Yr.

41-68 Address: ____________ 103-112 Telephone: ____ / ____________

69-91 City, State: ____________ Zip ______ (92-96) 113-121 S.S.N. ____________

Who can we contact if we need to get in touch with you in a hurry?

13-37 Name: ____________ 38-47 Telephone: ____ / ____________

BACKGROUND

48 Sex (circle one): male$_1$ female$_2$

49 Race: White$_1$ Black$_2$ Indian$_3$ Spanish surname$_4$ Other$_5$

50-55 Date of Birth ____________ Mo. Day Yr. Age ______

Circle your highest level of education:

56-57 Grades 3 4 5 6 7 8 9 10 11 12 GED$_{13}$

58 College? 1 2 3 4 Grad. Schl. 5 6 7 8

Have you had Voc. Tech. training?

59 yes$_1$ no$_2$ If yes—

Where? ____________

In what? ____________

Last school attended? ____________

Degree? ____________

60 Are you a veteran? yes$_1$ no$_2$

Type of discharge ____________

FAMILY

Marital status (circle one):

61 married$_1$ unmarried$_2$

Maiden or former name ____________

62-63 Number of dependents ____________

64-65 Number of people in your current household ____________

(If married)

Spouse's name ____________

Spouse's employment (if employed):

Occupation ____________

Employed by ____________

66-69 Spouse's earnings per month $ ____________

70-71 Number of dependent children in family ______

How many are ages 0 - 5? ______

ages 6 - 12? ______

ages 13 - 16? ______

over age 16? ______

REFERRAL

72-73 Referral Source (circle one):

1) VR	5) TS	9) Priv. Phys.	13) Family
2) CETA	6) TM	10) CMHC	14) Self
3) SR	7) VA	11) KC	15) Friend
4) Job Serv. Ctr.	8) GM&C Hosp.	12) Break Thro.	16) Other

Specific Source ____________

74 VR certified? yes$_1$ no$_2$

VR counselor ____________

75 Referred to VR from PWI? yes$_1$ no$_2$

MEDICAL

76-77 Type of disability (circle one): If more than one, circle the primary disability.

1) Visual	18) Back injury
2) Hearing	19) Colostomy
3) Amputation or limb absence	20) Speech impediment
4) Psychiatric	21) Cerebral Palsy
5) Alcohol/Drugs	22) Learning disability
6) MR	23) Epilepsy
7) Paraplegia	24) Stroke
8) Hemiplegia	25) Other circulatory or cardiac impairments
9) Quadriplegia	26) Respiratory
10) Cystic Fibrosis	27) Digestive (Ulcer)
11) Muscular Dystrophy	28) Muscular degeneration
12) Multiple Sclerosis	29) Arthritis
13) Diabetes	30) Brain damage
14) Blood disorder	31) Other (specify)
15) Cancer	
16) Renal failure	
17) Spinal cord injury	

78 Is client severely disabled? yes$_1$ no$_2$

Primary Physician ____________

Address ____________

out reports, and the hardware needed to operate the system. The basic software for this kind of system has become available recently and can be purchased for less than $300. However, agencies with extremely large caseloads and much data per case may require a more expensive storage system — the "hard" disc. Hard discs are expensive; with them, the total hardware cost is likely to be around $9,000.

Incidentally, there are lots of ways to protect client confidentiality when data are stored on the computer. The fact that you own the system and that the data are available only in your own agency is one safeguard. The machine can be programmed so that access to certain information is restricted to people who know a given password. The password can be changed as needed. In general, confidentiality is better protected when the information is stored on the computer than when it is stored in locked filing cabinets.

Business Systems

The same machinery that handles your client information needs also can handle your financial matters. The computer can do all the business arithmetic needed by most agencies: keep a general ledger; turn out financial reports; calculate the payroll — taxes, deductions, and so forth; print the payroll checks; print the forms required by the Federal and State governments; calculate how much a client or third party payer should be billed; and print the bill and mailing label. The computer can keep inventory listings and update them. The software for all of these functions is readily available and ranges in total cost from $600 to $2,000. The higher cost covers an "integrated" business system that feeds results from, for example, payroll into the general ledger.

Word Processing

The large commercial concerns that sell word processing equipment charge between $7,000 and $8,000 for their most basic machines. You can do word processing just as effectively with the $4,500 microcomputer system described above. With the microcomputer, you can:

- type text on the keyboard, read it on the TV screen, and correct it before it is printed.
- store text on discs or tape.
- delete passages and insert others into the text, with the printer printing the corrected copy.
- print letters made up of selected, stored paragraphs.
- print from letters with specific, individualized data entered where needed — e.g., name, age, diagnosis, marital status, etc.; and
- set up copy for newsletters that is right and left justified, so that the print ends precisely on the margins.

If you were satisfied with the print quality of your microcomputer printer, then a true "word processing" capability could be added to your system for about $200. This price includes equipment modification (so that both upper and lower case letters could be printed) and the software to do the job.

Note the qualification, "If you were satisfied with the print quality...." You might not be. Most printers for microcomputers create a letter by imprinting the paper with a pattern of dots. This is why they are called "dot matrix" printers. Such printers are rugged, versatile, and relatively cheap — currently starting at $700. Their print quality is acceptable for checks, W-2 forms, address labels, fiscal output, and similar pedestrian uses. But the print is not of typewriter quality; it *looks like* it came out of a computer, and it's not easy on the eye. This can be a problem if you want to turn out attractive newsletters or correspondence that shows you care enough to type the very best.

Printers that produce typewriter quality letters are available but expensive. The NEC spinwriter, for example, lists at $2,979; the Diablo daisy wheel printer costs $3,700. There are, however, three other options:

1. If you own an IBM Selectric II typewriter, it can be modified (at a cost of $400) to serve as an output printer.
2. If you have another brand of typewriter, you can purchase a device (for about $1,000) to fit over your typewriter keys. Solenoids in the unit depress the keys on computer command.
3. You can purchase a refurbished IBM Selectric Terminal for about $1,000.

Figure 4 illustrates the print quality for several devices.

FIGURE 4 Printer Output

This sample paragraph was printed by a Diablo printer, using a plastic Daisy Wheel and a HyType II carbon ribbon. It shows the letter quality attainable on reproduction. This and similar machines are capable of "proportional printing" -- a different amount of space is allocated to each letter, so that the final output looks more like set type. This example was both right justified and proportionally spaced, using the EasyWriter word processing program on an Apple II microcomputer.

For comparison purposes, this paragraph illustrates the letter quality of the IBM Selectric II typewriter or the MagCard/A word processor with a carbon ribbon. The Selectric II may be modified to serve as a printer; it is not, however, capable of proportional spacing.

This sample paragraph was printed by a Centronics 737 printer using the new n x 9 dot matrix format. A continuous loop cloth and ink ribbon is used. The letter quality print produced approaches that of a typewriter. Most machines currently using the denser dot matrix are capable of proportional printing. Varying sizes of type can be produced with these machines.

THIS SAMPLE PARAGRAPH WAS PRINTED USING A STANDARD DOT MATRIX PRINTER. IT ILLUSTRATES THE PRINT QUALITY ACHIEVED ON REPRODUCTION. FEW STANDARD DOT MATRIX PRINTERS ARE CAPABLE OF PROPORTIONAL PRINTING, BUT MOST ARE ABLE TO PRODUCE VARYING SIZES OF TYPE.

For day-in, day-out use where you require high speed and rigid durability, none of these low-cost options is recommended. Typewriters have many moving parts; they wear out quickly if in constant high-speed use. If, however, you want word processing capability only, then a typewriter may suffice. It is also possible to use a dot matrix printer for most applications, but retain a modified Selectric typewriter on a standby basis for word processing needs.

Decision Support Applications

Assume that you have set up a client information system and a business system. You have nearly instant access to reams of data about your clients, the services they have received, and the disposition of cases. You have equally quick access to current income and expense information. Such information is useful not only for day-to-day operations; it also can be vital to planning and policy setting. The administrator and planner have access to the data needed to answer such questions as the following: Are certain kinds of clients underrepresented? Is the agency receiving referrals from the people who should be making referrals? How many clients drop out of the program? Who are they? Are some of the programs overfunded and underproductive?

The machines are not only capable of spewing out reams of data; the $4,500 system described above is also capable of aggregating any data you need and providing summary statistics. Programs are also available, for example, to forecast future caseloads or future costs on the basis of past trends and cycles.

The problem with these applications is not in the hardware or the software. The problem is in defining what information is needed to evaluate current program operations or plan new programs. What data? What summary tables? What statistics? Making sure that the necessary data are collected is part of the "headware" task as discussed in Chapter 3.

Blue Sky Applications

This category includes applications that are a bit out of the ordinary but are available or will become available in the next few years. Already the bigger computers can administer, score, and interpret a variety of psychological tests and inventories. The software for these functions has not yet been written for microcomputers — but it will be. Routine interviews and surveys have been conducted by computer; it appears that in general people give franker answers to the machine than to a human interviewer. The software that enables the microcomputer to conduct such interviews is not yet available — but, again, it will be. Equipment is now available that enables different microcomputers in different agencies to transfer information over the telephone. This function is not yet commonplace, but if problems of territoriality and confidentiality can be worked out, it will become so. This capacity to exchange information by telephone means that microcomputers can hook into various computerized library "clearinghouse" services and thereby have instant access to, for example, annotated references on program evaluation, on projects currently funded by the U.S. government, or on educational innovations. By the same process, the microcomputer can communicate with the very big computers over a long distance telephone line, making the computational power of the big main frames available to any agency.

The costs for telephone linkup? About $300 for the communication devices and associated software.

More About Hardware

The preceding section suggests that unless your agency handles a vast number of clients, the microcomputer hardware needed for all applications should not cost more than $4,500. This section examines the hardware making up such a system and introduces some new terms to describe it.

First of all, you will want the computer chip plus keyboard. In the trade this is called the central processor unit (CPU). In it you want a group of memory chips to store your program and data. These chips are contained on a "memory board" and come with different storage capacities. When manufacturers describe the size of their computer systems, they do so by citing random access memory (RAM) capacity. The higher the RAM, the greater the cost of the system.

A random access memory allows you to read in data, access it quickly, and read it out again. Another kind of memory chip, widely used to store built-in instructions which will be used over and over by the machine, is called a read-only memory chip or ROM. You cannot put any data *into* a ROM chip; you can only get information out of it. The BASIC programming language in your computer is stored in ROM.

In microcomputers the storage capacity of RAM is expressed in an odd-sounding but easily understood form — for example, "16K RAM." "K" stands for 1,000 (specifically, 1,024) strokes on the keyboard. Alphabetic or numeric characters, spaces between words, carriage shifts, and so forth all count as strokes. These strokes are called "bytes." So, when you ask for 16K RAM you are specifying a random access memory board capable of storing approximately 16,000 keyboard entries, or 16K bytes.

You also want a television screen so the computer can communicate with you. In the trade this is called a cathode ray tube (CRT). It's just your old, familiar TV set, slightly modified for computer use.

What follows is a hypothetical illustration. By the time you read this, prices may have changed — probably in a downward direction, since computer equipment keeps getting cheaper in spite of inflation. Retail prices are quoted, even though much of the equipment is available at a 10 to 15 percent discount. Finally, although specific manufacturers and products are cited, the authors neither endorse this equipment nor denigrate competitors.

First, let's make some assumptions about a "typical" agency. Assume that your agency sees 500 new clients a year, and none for a longer period than 5 years. Assume also that you want to store 100 items of information about each client on the computer — name, identification number, address, phone number, diagnosis, referral source, presenting problem, treatment modality, and so forth. Assume that you have developed the forms so that most of this information can be entered as numbers rather than as text. Assume further that in 5 years you would have collected 100 items of information on 2,500 clients — 250,000 items of information in all. This means you will need to use disc drives rather than tape to store the data. Finally, assume that you wish not only to read the information on the computer's TV screen, but also would like it printed. With these assumptions, it is possible to cost out the hardware to do the job.

You also will need to store large quantities of data. You could of course use a standard cassette recorder and store the data on tape, but that is a time-consuming and frustrating task. You no doubt will want disc drives. For the applications cited above, two double-sided, double-density, eight-inch drives would be needed. "Double-sided" means that you can read both sides of the floppy disc without removing it from the drive; "double-density" means that the disc can contain a large amount of data.

To operate the disc drives (and other peripherals), you also need an "interface." The interface contains sockets and electronic circuits that enable you to plug in different kinds of machines. It also has ROM chips that contain special instructions to operate the disc drives. In this application, you would probably wish to increase your machine's memory capacity from 16K RAM to 32K RAM, so you would specify that an additional 16K RAM be added to the interface. Combined with your original 16K RAM in the CPU, this gives you 32K RAM resident in the computer.

You will also want a printer. For this hypothetical case assume you purchase a Paper Tiger from Integral Data Systems Inc. for $995. Like many printers on the market, the Paper Tiger uses standard fanfold paper, can type in upper or lower case, and prints in eight different character sizes.

Finally, just for the sake of convenience, you might purchase a separate desk for the system. The desk is not strictly necessary, since the equipment is compact enough to sit on a kitchen table. You should also include a power line filter, a voltage regulator, and a single switch to turn everything on and off. The first two items help protect the equipment from errors caused by power surges, or from the kind of electrical interference that affects your television transmission when somebody is running an electric motor nearby. The switch is a simple convenience, so you do not have to turn on each piece of equipment separately.

The total cost of this microcomputer system? Just $4,568 — about the same price as four IBM Selectric typewriters.

Such expenditures are clearly within the reach of most small or medium-size agencies. Hardware costs are no longer a real problem. But, as has been hinted before, hardware costs have never been the major problem. Other very real costs — in time, effort, morale, and money — have to be considered. These are the subject of the next chapter.

II. DEVELOPING THE MICROCOMPUTER SYSTEM

Microcomputer hardware is now within the budget of most small and medium-size agencies. Does this mean the millenium has arrived when every agency will be able to do brave new things? Hardly.

Every so often, in workshops and consultations, agency staffers make comments like this one:

> I'm convinced my agency could use a computer. We have files full of client data which we have no time to analyze. We have a real problem in proving that our services are effective. The computer can solve that problem. So I plan to request a $5,000 allocation for a microcomputer system at our next board meeting.

Implicit here is the idea that the hardware will solve these problems by itself — wonderfully, magically, untouched by human thought. Unfortunately, it does work that way. The computer has no magic; in fact, it's an incredibly dumb machine. Fast, pretty, but dumb. It does only what it is told to do, literally and in painstaking detail. The computer is quite capable of doing 5,000 computations a minute — all of them wrong.

So how do you get the machine to do what you want it to do? First, you have to figure out what the computer is supposed to accomplish for the agency. Then you have to get very concrete and decide on the specific pieces of information that need to go into the machine; the specific ways that the information should be collected; the specific computations, sorts, or listings to be done using that information; and the specific ways the information should be printed out. Then someone has to translate these specific expectations into step-by-step instructions for the machine. And someone has to set up the agency procedures — new forms, new roles, new tasks — that ensure that the information gets collected, put in the computer, processed, and reported.

The first of these tasks — deciding what the computer can do for your agency — is part of the systems analysis effort. Systems analysis is the process of defining the agency's computer needs, designing a computer system to meet these needs, and making sure that the design gets implemented in good order. Since systems analysis requires rational thought and some creativity, it is called the "headware" task.

The second task is the writing or modifying of specific programs to tell the machine what to do and is obviously the "software" task. The third job — setting up the computer system so that the staff is happy with it rather than burdened by it — might be called the "staffware" task. If the "staffware" task is done right, most people in the agency will have had a say in how the computer is to be used, will find it useful in doing their own work, and will come to regard it as a helpful tool rather than a pain in the neck.

These then are the three big issues that agencies face with microcomputer systems: not hardware — but headware, software, and staffware. It is these issues that can cause you grief and run your budget in the red. They emerge at each step in setting up a microcomputer system.

The Seven Steps to Implementation

Let's look more closely at the process by which you get your microcomputer system up and running, and at the decisions to be made in terms of headware, software, and staffware. The process can be broken down into seven steps.

Step 1: Developing the Initial System Specifications

The first task is to describe, *in general terms,* what the system is to do. This is sometimes called the "user need statement." If you have completed the form in Figure 2, you already have made a beginning. Now you need to prepare a formal document that gets down to details. This document should tell what routine reporting forms are to be prepared by the machine, and when. If certain kinds of client data should be available to agency staff, then you should describe the kinds of data needed and why they should be "on tap" (rather than, for instance, just available in the case folder). If you have business applications, the nature of these should be specified: How many clients per year? What is the size of the payroll, etc. In short, preparing the initial system specification requires that you think through, quite carefully, how you really want to use the computer.

Along with describing what the computer must do, the initial specifications document should note your *constraints and priorities*. State your budget limitations. State if some parts of the system need to be implemented quickly, while others can wait.

Why prepare a formal document? It serves two purposes. First, it helps you communicate with computer consultants and other technical personnel. The better they know your needs, the better they can serve you. Second, it helps you communicate within your staff. If the document is circulated and discussed, and if staff members have a chance to modify it, then everybody will be happier with the end product.

Often, at this beginning stage, agencies find it helpful to schedule a half-day training session to introduce the staff to the microcomputer and its potentials. If a microcomputer consultant/systems analyst is working with you, that person can run the meeting. At this first meeting, the consultant should bring along a microcomputer system to show what it can do. Apart from show-and-tell, some of your staff members may enjoy playing computer games on the machine; it makes the whole thing seem less mysterious. In addition to providing an introduction to microcomputers, such a training session serves several less obvious purposes. First, it communicates to the staff that you are serious, that this new thrust is important, and that it will eventually influence what goes on in the agency. Second, it gives the staff a chance to ask questions, vent feelings, and clear up misconceptions. Finally, it provides a bit of basic and useful lore, so that staff people can start thinking about ways the computer can help them do their own jobs better.

Step 1 thus serves two purposes: (1) it gets you started on the headware task, and (2) it sets the stage for staff involvement and input, making later staffware tasks possible. Clear thinking about your needs and careful preparation of your initial specifications together constitute the most important step in the whole process. Step 1 provides the roadmap for all that follows.

Step 2: Looking at What Is Feasible

Having decided what your system should do, the next step is to look at — and price — the different options. You need to look at both hardware and software. For most agencies, the software is more important than hardware. If the software package you need is written for machine A then do not purchase machine B; software conversion is expensive.

In studying feasibility; the wise administrator will rely on a systems consultant and not on the local microcomputer salesperson. Salespeople are anxious to sell their own product and are likely to denigrate competing products. They will know most about some software for hobbyists, the latest in computer games, and some standard business packages. A good consultant, on the other hand, is familiar with a much wider range of hardware and software, or at least knows where to find the information.

The end-product of Step 2 will be a tentative decision on the hardware configuration you need, its likely cost, and the software packages required to accomplish specific tasks.

Step 3: Designing the System in Detail

From Steps 1 and 2, you know what you want done; you are assured that there is hardware and software to do the job, and you are satisfied that your high priority needs can be met within your budget. Now comes the hard part — designing the specific system in detail. The two key words here are "specific" and "detail." You and your consultant need to figure out what items of information, collected by whom and when, should be entered on which forms. You and your consultant need to figure out who will enter the data on the computer, who will be responsible for the computer operations, how these people will be trained, and how their activities will be supervised. You and your consultant need to figure out what information, processed how, should routinely be reported to whom, in what format, and when. This detailed system design is based upon the roadmap document developed in Step 1; the system can only be as good as that map.

However, the detailed design goes a long way beyond the original effort and requires a new level of cooperation from agency people. The systems consultant needs to know about the agency in exhaustive detail. This can pose great demands on your time and that of your staff. If the systems analysis is done by an outside consultant whom no one trusts and who fails to understand the agency, it can result in an unusable system. If the analysis is done right, it can result in a system that the staff feels they own and that meets their needs. Even at best, however, systems analysis is a time-consuming process.

In completing Step 3, the systems analyst will have outlined a proposed information system for the agency. Usually the new system requires that some forms be redesigned, that some staff have new responsibilities for reporting data, and that some clerical and supervisory needs be changed to accommodate the new tasks.

Change is always threatening, and no change is more threatening than that imposed from above. At the minimum, everyone whose job is affected by the new procedures — including everyone who will use the computer's output — should review the design, understand it, and have a chance to suggest modifications. They need to ask critical questions: Does the system accomplish what it is supposed to accomplish? Has the designer been realistic in his or her assumptions about staff needs and staff time? Have any problems of implementation been overlooked? Do the new forms make sense? An early effort to work through these questions can head off weeks of trauma later.

A word is needed here about the special problems of form design in human service agencies. Designing forms that people fill out is no major problem in business concerns: the same old information is simply recorded in new ways. Human service agencies face more subtle problems, and sometimes even simple face-sheet forms go through three or four revisions before they are acceptable. Tricky ambiguities can arise in coding such straightforward variables as "type of disability" or "service received," and coding more subtle variables such as "presenting complaint" can pose very special problems. People have to agree on what is meant by particular words. Thus it is usually necessary to try out the new forms, revise them, try them out again, and revise them further.

Therefore, form design should start as soon as possible during Step 3. The initial, trial version of a new form need not be polished — one only needs to be sure that it includes the data specified in the system design. Duplicate 20 copies of each new form and try it out with real clients. Don't abandon any of your other recordkeeping procedures at this point; simply treat the new form as an experimental add-on. As you accumulate the completed forms, check them for obvious misunderstandings and ask the staff about problems encountered in filling them out. No doubt you will uncover numerous problems. Revise the form and duplicate another 20 copies. Repeat the same procedures. Do this until you and the staff are satisfied with the results. Only then take the new form to the printer.

Step 4: Developing the Software

In Step 2 you will already have identified applicable software packages. Most of these will be general purpose programs, designed to meet everyone's needs — in general. Unfortunately, you may find that no software package totally meets your own needs in particular. If so, software will require modification. Software packages and their modification are discussed later in more detail. At this point simply note that some modification may be necessary, and a good consultant can arrange to have this done.

Step 5: Making Sure It Works, and Stays Working

Assume that Steps 1 through 4 have been accomplished. You have the hardware; you have the software; your staff is convinced that this is a great innovation. Are you now at the end of the road? Experience has shown that the answer is no.

Systems analysts tend to be pessimistic folk, fond of such mottos as "If a thing can go wrong, it will" and "Nature favors the hidden flaw." This is for good reason; their daily work confirms the truth of such verities. It is fair to say that few computer systems work right the first time; few programs run right the first time; few office procedures run smoothly when first implemented; and new forms are never free of ambiguity. The system needs to be tested, modified, retested, remodified — in the jargon of the trade, "debugged."

It takes a long time to get all the bugs out of a new information system. It is not uncommon for problems to emerge a year after the procedures are in place and operating. But the bulk of debugging should take place at Step 5 — after the programs are written and before they are put into operation. The conscientious consultant works with the programmer to test software and its modifications. The programmer runs the software with sample data to make sure that the information is stored appropriately, that the results are correct, and that the output formats are as specified. Initial debugging catches the obvious problems, but not all the problems are obvious. Therefore, the conscientious consultant also stands ready to help the agency with other problems that emerge over time.

In addition to debugging the programs, "documentation" needs to be prepared. This is a fancy way of saying that somebody — the consultant or programmer — needs to set down on paper what each piece of software does, how it works, and how to get it running. Most commercial software comes with documentation already prepared. However, additional documentation is often needed to describe program modifications, and sometimes existing documentation needs to be expanded or translated out of computer jargon into English.

Good documentation is as vital as good programming. Your staff can operate the computer only if the procedures are described clearly. And later on, as new staff or new consultants come aboard, a good description of the system and its workings is essential. Otherwise the computer just sits there, and the only person able to run it may have departed to Saudi Arabia.

Step 6: Conducting the Shakedown Cruise

Having completed Steps 1 through 5, you are now ready to launch the microcomputer system "for real." In other words, you have reached the stage of "conversion" and "implementation." You are ready to train the computer staff and embark on the shakedown cruise.

Most of the tasks of Step 6 are obvious. The person running the computer, and the person responsible for supervision, must learn about the system and how to operate it. The documentation provides the textbook, and your consultant can provide the training. The new data forms, painfully tested and revised over the preceding weeks, are put into use. The data are entered into the machine, reports come out, and people get used to the new order of things. The systems consultant stands by anxiously, ready to confront any problem that emerges.

A shakedown cruise makes special demands on the crew. Your agency staff is learning new things and struggling with new procedures. Anxieties and fears about computers are likely to reemerge during this period, and old beliefs ("this system is being foisted on us") can reappear in virulent form. The more the staff has been involved in Steps 1 through 5, the less of a problem there will be. Nevertheless, the administrator should anticipate some static. A sympathetic ear and kind firmness may be required.

The administrator also needs to be aware of two fatal mistakes that can be made during the shakedown cruise. First, with the new system beginning operation, there is a strong tendency to discontinue immediately the old, manual ways of doing things. This is always an error. It is best to go gradually and continue the old procedures until the new system has run for a while and the most obvious bugs have been worked out. Remember the programmer's maxim: "If something can go wrong, it will."

The second fatal mistake is to use the initial output for heavy-handed management. The first reports will probably highlight problems and flaws in the agency. This is to be expected — if the agency ran perfectly, why bother with a computer? The naive executive may panic when confronted with stark evidence of program problems. People get called on the carpet, old "tried and true" procedures are summarily discontinued, and an organizational shakeup ensues. This seems logical, but in fact it may be fatal. There is no easier way to kill a new information system than to use its results punitively. The staff quickly learns to sabotage a punitive system.

Step 7: Planning for Later Modifications

Life, agencies, and procedures change. The information system that meets your needs today may not do so tomorrow. Pressures for change will develop over time. Modification and updating of the system is listed as Step 7, but in effect it returns you to Step 1. Systems modification requires a clear specification of new needs, a partial assessment of feasibility, a new analysis and redesign effort—in short, a small-scale retracing of the six procedures listed above.

There has been much discussion of staff reactions and staff involvement in these seven steps — and for good reason. All too often, the introduction of an information system is viewed as an engineering job — a job for superrational, supercognitive, unemotional technicians. No good systems analyst believes such nonsense. Computer systems are built for people, used by people, and succeed only when people want them to succeed. People are not superrational; they are not supercognitive and unemotional. Their feelings about the computer determine its fate. Therefore, computer systems imposed from above have a poor prognosis. Systems that threaten the staff will be sabotaged. After reviewing some 200 descriptions of computer systems in human service agencies, Bowers and Bowers single out "the most predominant point made in the documents."

> It is essential to involve management, service delivery staff, and all other potential systems users in all parts and phases of systems developed, par-

> ticularly the design phase.... If the system is not meaningful to the user, if it is not related to his/her work, if he/she does not contribute to its design or does not feel a stake in its development, it most likely will fail.[3]

The Necessary Consultant

You will have noticed that the preceding section introduced a new character — the computer consultant/systems analyst. This is "the person whose job it is to define a data processing problem, design a computer system to solve it, and hold your hand while it is being implemented."[4] For an agency wishing to develop its own microcomputer system, the systems consultant plays an essential, even a starring, role.

The ideal systems consultant has the technical wizardry of Thomas Edison, the organizational savvy of Peter Drucker, and the humane empathy of Karl Menninger. And then, of course, there are the rest. They come in all sizes, shapes, colors, and genders: often with a background in computer hardware or software, occasionally with a background in business or social agency administration, rarely with a background in both. Many consultants operate as sole entrepreneurs; some are embedded in consulting firms; others moonlight out of universities. Few consultants as yet specialize in microcomputer applications, and still fewer specialize in the needs of small and medium-size social agencies. Thus, as a group, systems consultants fall short of the ideal. Like lawyers or physicians, they are not infallible; they only are necessary.

The agency administrator needs to find the best available part-time systems consultant. Big corporations and hospitals simply go out and hire their own experts full-time, or they may sign hefty contracts with reputable consulting firms. The small human service agency is in a different league; it needs a consultant rather than an employee. This kind of consultation is a new field. No microcomputer consulting firms have had time to build a strong reputation, and many would-be consultants are simply bright hobbyists picking up extra money. Thus there are no established routes for finding a consultant, and the administrator needs to shop around. One way of doing this is to phone the microcomputer stores in your metropolitan area and ask for names of systems consultants. The computer stores usually serve as hubs in the informal network of microcomputer users. Sometimes store owners will tell you that they offer such services themselves. You can also contact the computer sciences people at your local university, some of whom may have become intrigued by microcomputers and have knowledge for sale.

As in hiring any expert consultant, it is useful to ask some preliminary questions. What is his or her real area of expertise? Is this person a careful, thoughtful listener who seems to understand your particular concerns and needs? For what other organizations has he or she worked? Can you contact these organizations to see how well the job was done? Avoid the fast-talking operator who tries to snow you with technical jargon or optimistic promises.

At best, your consultant will have some limitations. Few people who know a lot about microcomputers and systems analysis also know a lot about human service agencies. However, this situation is likely to change. Already, some people with training in the social services are becoming expert with microcomputer systems. Our own consulting group, for example, includes two clinical psychologists and one social worker. Some universities are contemplating new training programs in the field. But right now the single major barrier to mounting your own microcomputer system will probably be the scarcity of systems consultants who know microcomputers *and* social services. There are three possible ways to deal with this problem:

1. You can restrict your aims and settle for a microcomputer system that uses what your consultant knows. The typical consultant will have had experience with business application and can help you set up such applications for your microcomputer.

Similarly, it is easy to set up your computer to do word processing. This requires minimal consultation.

2. You can hire a consultant and have him or her learn about the agency and its operations. This is in fact what big businesses and hospitals have done — sometimes with indifferent success. It is a time-consuming and expensive route, but it may be the only way to go.
3. You can assign one of your own staff to work with the consultant in designing the system. Your staff person should know the agency and its procedures well and should have the confidence of the director and staff. This person should be able to think in administrative terms, should enjoy solving intellectual puzzles, and should be good with details. A bright person who is interested in program evaluation often makes a good systems analyst. Your staff member can do a lot of the systems analysis and design work under the consultant's supervision.

There is yet another option, but it hardly ever works. Some microcomputer advertisements imply that anyone can do programming in BASIC for any purpose — Programming Can Be Fun! It is true that any intelligent person can learn enough BASIC in a few days to balance a checkbook by machine, just as anyone can learn some useful things about law in a few days. Still, any layperson who tries to be his or her own lawyer has a fool for a client, and any administrator who tries to be his or her own systems analyst and programmer has the same problem.

Which of the three viable options you choose depends of course on your needs. The first option works well if you are interested mainly in business applications. The second option is feasible if you can afford it. But in general the third option is the best, provided you have the right person on your staff and can realistically free his or her time. The third option is usually the most cost-effective, since it is harder for an outside consultant to learn the details of your agency than it is for your person to learn a bit about systems design.

Option three has other advantages. It allows the person who will ultimately manage the system to be involved from the beginning. Having this person aboard reassures the staff who would sooner trust a sympathetic colleague than an unknown outsider.

However, option three also has its pitfalls. The staff person's time allocation must be realistic, and it must be carefully guarded. All too often time gets eaten away by other agency duties. Also the consultant must be capable of providing responsible supervision, assigning realistic tasks, and demanding reasonable schedules for their completion.

The 1990 Option

These are the three options available now. None of them may in fact meet your needs. However, in the next 5 years another innovation is likely to emerge. No one can promise it, but if it comes it will simplify microcomputer applications for small and medium-size agencies. It is called the "turnkey" human service information system.

Currently, any agency wanting a microcomputer-based client information system has to design its own. The process is akin to purchasing a tailored suit: you go to a tailor (the consultant); you describe what you want (the initial system specifications); you look at different styles, costs, and materials (feasibility analysis); your body is carefully measured (system design); the component parts of the suit are cut precisely to fit you (software development); you go through several fittings to make sure the garment feels and hangs right (debugging); and then you get used to wearing it (conversion and implementation). You have purchased a unique product, quite literally tailored to your needs. It fits well, but it is not cheap.

With a suit, you have a simpler alternative. You can go to your neighborhood clothing store, specify your size and fabric preference, and try on several garments from the rack. The suit you buy will not be custom designed for your unique dimensions. Some alteration will be necessary, and it will seldom fit as well as the tailored product. But it will serve, and you will have saved over half the cost.

As with suits, so with human service agencies. Every comprehensive community mental health center and every full-care nursing home, like every individual body, is unique. Nevertheless, all full-care nursing homes have much in common, as do all comprehensive community mental health centers. In principle, it is possible to design a microcomputer-based information system that will generally meet the needs of the average full-care nursing home. Some alterations will be necessary, but the cost will still be less than the custom model. The same principle holds true for many other types of social agencies. Such a generic system is sometimes called a "turnkey" package; you "turn the key" on your computer and you are up and running.

Turnkey systems for human service agencies do not yet exist. Given the market, however, it is likely that they will become available within this decade, at least for certain kinds of agencies. By the end of the decade some consulting firms may specialize in such systems. Thus the cautious agency administrator has a final option: to sit pat, do nothing, and wait. Maybe by 1990 all your needs will be met by a turnkey system — or maybe not.

III. APPROACHES TO SYSTEM DESIGN

This chapter is vital if you wish eventually to examine data about clients or about agency services or if you want to use such data for program evaluation, program monitoring, or agency planning.

Word processing and business applications are well standardized, highly conventional, and require little design effort. Appropriate programs are available for most microcomputers; they are well documented and easy to use. For business needs, consulting help is widely available, and the agency executive and/or the agency's fiscal officer should have no trouble preparing the initial system specifications.

If, however, you want an information system for client data or for program planning, you are going beyond the conventional. New issues arise. Suppose, for example, you need to track clients through your agency's services. Or you want to have certain kinds of client listings available at the push of a button. Or you want aggregate information about the cost of particular services to help you set rates. Or you want to examine referral sources to see who is (or is not) making use of your agency's services. Such needs require that you invent something new, use new data in new ways. Existing software may not be appropriate. Designing such information systems is likely to prove time consuming and costly if you start from scratch.

Given these problems, it is useful to look at the approaches used by different agencies to "invent" nonconventional client information and management information systems. Their experiences provide many a cautionary tale.

Traditional Big System Approaches

In the past, most client information systems and most management information systems were developed for big social service bureaucracies or for complex psychiatric settings. Some highlights from history follow.

The Automated Case Record Approach in Psychiatric Settings

Computers were used early to produce an "automated case record." Every important piece of client data was put on the computer so it would be accessible for treatment and research purposes. But who defined what client data were important? Obviously a committee was needed. Committees met, struggled with the task, and decided to store vast quantities of information for each client. The results were seldom salutory. Clinicians were required to fill out interminable forms. New personnel were hired to code and keypunch the data. More discs and tape drives were added for tape storage. Costs skyrocketed.

Then, another question arose: Now that all this information was collected, how could it be used? It turned out that little of the data had any practical, immediate utility. The problem here was that the system had been designed backwards. They began by asking, "What data should we collect for input into the machine?" They should have begun by asking, "What output do we need?" Most people now believe that the "automated case record approach" was the wrong way to go.

The Incremental Approach

Other agencies took a different tack, using an incremental or "piecemeal" approach. Generally they began by putting their business operations on computer. That done, they moved to other applications. For instance, a State mental hospital might hire one outside contractor to develop a payroll and billing system, and a few years later hire another contractor to develop a patient-tracking system. With the incremental approach, each system was designed separately and operated separately. Each used different forms, stored its data in a different format, and used different processing operations for different ends.

This piecemeal development of systems led to problems. Often the same item of information was needed on two or more systems, so the staff had to complete redundant forms. Rather than reducing paper work, the computer increased it. Often, too, there was no way of merging data from the different systems. If the fiscal information was on one system, the client transfer data on a second, and face sheet information on a third, it was often impossible to look at the cost-effectiveness of different programs or at the flow of different kinds of clients through the system. There was an obvious need for system compatibility.

The MIS Approach

To overcome the problem of incompatibility inherent in the incremental approach, a new strategy of system design emerged, called the management information system (MIS). Its basic idea was simple: store all the data needed by every application in a single set of discs or tapes, thus providing an "integrated data base." Data from anywhere in the agency could be put into these linking, automated "files," giving a pool of information that could be used for different purposes and for different kinds of processing. The pooled data could be used for routine applications: to generate payroll, bill clients, provide special client listings, generate summary reports, and so forth. It could also be used to answer management questions or provide routine reports to aid the management decision-making process.

It seemed like a good, simple idea. In practice though it turned out to be very complex. First, it made exceedingly heavy demands on the group who designed the system and prepared the specifications. The design group had to consider every issue of importance to the agency before the system could be constructed or implemented. This was like having to map out an entire city, and specify what was on each block, before constructing a single house. One large MIS, designed to handle State Medicaid programs, needed five thick volumes simply to describe the initial system specifications. Such systems turned out to be extraordinarily complex — and expensive.

And basically, an MIS is warranted only if management can really use the information it provides. This is not always the case. A few years ago, a consultant visited a progressive western State to see how its umbrella agency was using the Medicaid Management System. The consultant discovered that the management reports were never used. Said one informant: "No one has sat down to figure out how to use the data they are getting from the systems. The toughest part is not putting in the system and generating reports. The toughest part is getting people organized to use all that information." Said another: "The program management reports tend not to be used.... There is no manual telling how they should be used, nor is any person responsible for using them."

Similar problems of utilization have been reported in the business world:

> Not all organizations are prepared to deal with stark reality. One corporate division, for example, terminated a long-range planning activity that made sales forecasts...because it preferred optimism to factual analysis. It apparently was not prepared to change either its aspirations or its practices to cope with the data presented.[5] (p. 9)

It is pointless to build a better mousetrap if no one wants to catch mice.

Given these difficulties, the bloom soon faded from the MIS rose. Private industry came to view such systems as overly complex and ambitious, and the large public bureaucracies came to see them as needlessly cumbersome.

The Modular Approach

Most recently a new approach has emerged, melding the best features of the incremental approach and the MIS approach. It goes by various names, "modular design" and "structured programming" being the most common. In essence it uses an incremental, step-by-step strategy of system design, but each step is guided by a master plan.

In this strategy, every major software piece is designed for a particular, specialized application. The major software pieces are called "modules." For example, one software module might be developed to handle payroll, another to handle client face sheet information, another to handle staff time utilization data, and so on. Each module is developed separately and operates autonomously. The most important modules may be developed first, the less pressing ones later. However, all modules are programmed to share a common set of storage files — an "integrated data base." Since they all share a common data base, any module can draw from, or contribute to, the total pool of information.

The modular approach to system design clearly preserves the advantages of the MIS strategy, while allowing the system to be developed in an incremental and phased way. Although modular design requires preparatory planning, the plans can be changed: new modules can be developed for new applications, and old modules can be revised. Since any piece of data needs to be entered only once into the system, modular design eliminates repetitious data collection, entry, and storage. Apart from the obvious need for initial planning, modular design has only one constraint: the input/output programming for the various modules must be compatible.

In summary, past experience with large scale applications has pointed to major problems with the "automated case record" approach, the "piecemeal/incremental approach," and the MIS approach. Modular design strategy overcomes these major problems. When an agency wishes to get full benefit from its microcomputer system, and when it is willing to do long-range planning for computer utilization, the modular approach is generally preferred.

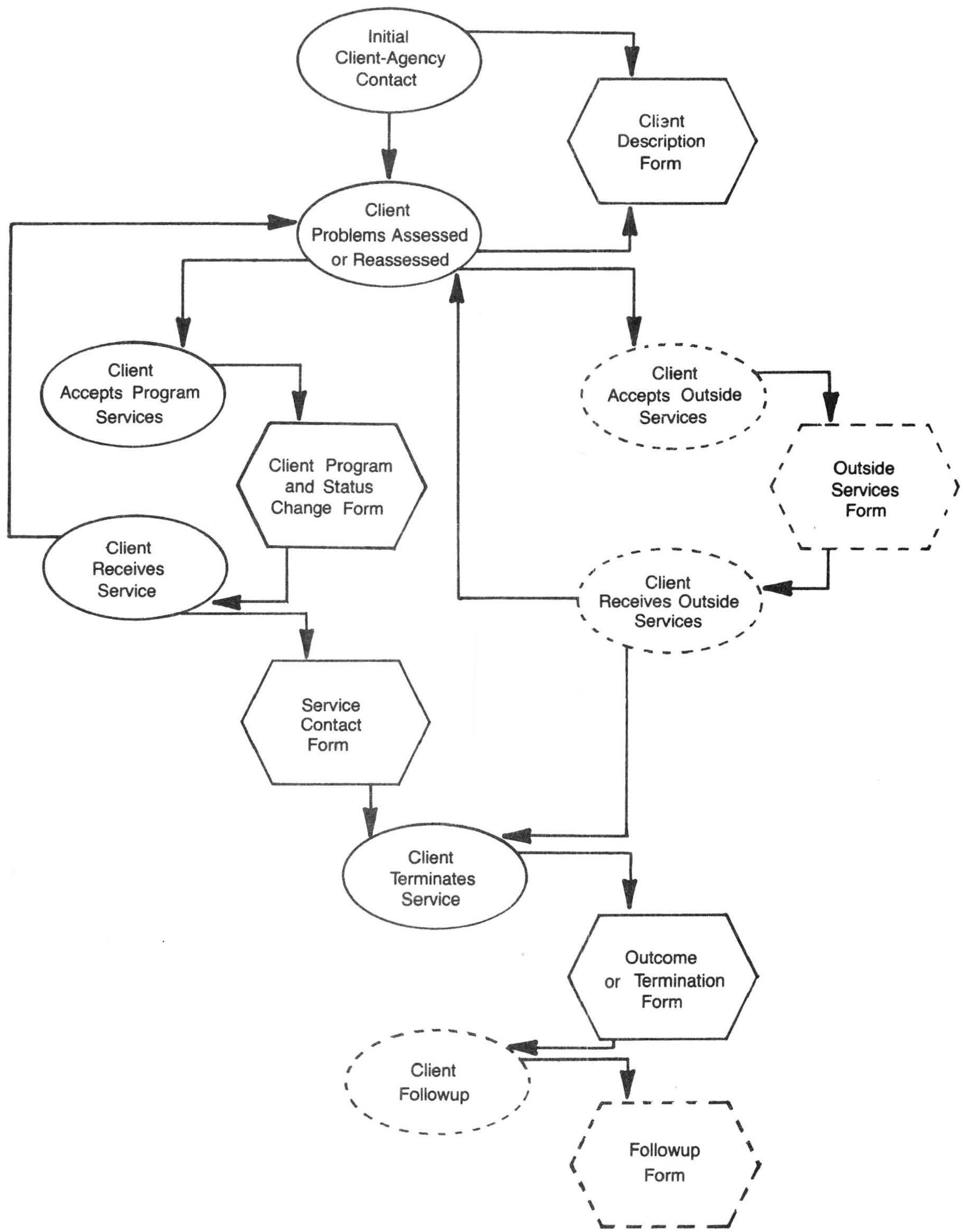
Modular Design for Human Service Applications

What kinds of modules are needed to plan a human service information system? To answer this question it is useful to look at the world through the eyes of a systems analyst.

Assume that you are a systems analyst asked to consult with a human service agency — any human service agency. You are called in at the beginning to help the agency plan its microcomputer system. In your initial consultation you would learn a great deal about the unique problems of that agency but you would also observe some patterns of information acquisition, flow, and use common to such agencies. For this discussion let's concentrate on those items common to most agencies.

Assume further that you have probed enough into the agency to understand how it functions. At some point in your analysis you would probably draw a diagram, much like Figure 5, to show the path followed by clients seeking agency services and the kinds of information generated along that path. The ovals on the left show the agency processes; the boxes on the right show the kinds of forms typically generated by these processes. (Shapes drawn with dotted lines indicate events and forms that are sometimes, but not always, present in human service agencies.)

FIGURE 5 The Client and Form Pathway



In addition to drawing the type of diagram shown in Figure 5, you might attach a sheet that describes the kinds of information contained in the forms:

1. **The Client Description Form** — gives important background information and tells something about the problems that bring the client to the agency.
2. **The Client Program and Status Change Form** — gives information on the services or programs in which the client is "enrolled," and indicates changes in status (for example, moving from one program or setting to another, "dropping out," etc.)
3. **The Service Contact Form** — gives information on the time, data, and duration of service delivery, and indicates who delivered the service.
4. **The Outside Services Form** — gives information on the client's referral to and receipt of relevant outside services utilized by the agency. (Optional, but used especially by those agencies that purchase or use services external to the agency.)
5. **The Outcome or Termination Forms** — gives information on the client's status and problems after a certain length of service and/or termination of service.
6. **The Follow-Up Form** — gives information on the client's status and problems at some set time following termination of service. (Optional, used especially for program evaluation.)

During later stages of system design you will expand on parts of this diagram by getting quite specific about the particular pieces of information (the "data elements") that need to be collected. But for now, this rough outline serves your purpose well enough.

On the basis of this diagram you know that six pieces of modular software must be written. This allows the secretarial staff to enter information from the forms into the microcomputer. Each type of form will need a separate software module, although all modules will be hooked into a single input/output program to assure compatibility.

Having gained a general idea of the agency operations and the data they generate, you now turn to the output side. What kinds of information do people need or want to know? Your prior agreement with the agency director allows you to confer confidentially with anyone on the staff, but of course you talk first with the director. You discuss agency needs and solicit advice on who should be seen next. You confer with service staff and with business office personnel, with supervisors and line workers, with typists and psychiatrists. At the end of your discussions, you see the need for a number of different modules, as follows:

1. Some staff members will need information about specific clients, their problems, the services they receive, and their history with the agency. Generally this information is wanted by service staff. They need it to write referral letters or case summary letters, to find out what other services their clients have received, or to check how long it has been since a client's last appointment. Supervisory staff also want case-level information — for example, to find out which staff person is working with a particular client, or which clients have completed a time-limited service. The client-level information is usually needed right away, preferably "at the push of a button." Seldom is the need for such data routine; rather the worker requires a very flexible program that allows specific inquiries of the data base. Software must be supplied for this purpose. You note the need to write an "interactive inquiry module."

2. The agency is required to submit routine reports to the State and Federal governments. In addition, the board of directors asks for special reports from time to time. All of these reports are compiled by aggregating information. The typical report details how many clients, of what kind, received what kinds of service between such and such dates. The program supervisors in the agency also feel a need for aggregate-level reports. For example, they would like up-to-date information on the number of clients currently in their unit or how many clients are assigned to each worker. They also need up-to-date information on their unit's budget in order to avoid embarrassing surprises.
3. The business office personnel have other specific needs. They send bills to clients, with the figures adjusted to a sliding fee schedule. Other bills are sent to third-party payers. They want the microcomputer to do the billing. The service staff sometimes provide chargeable services but neglect to inform anyone; as a result, income gets lost. The business office people hope the computer will correct this problem. In addition, the business staff have to prepare the payroll, calculate deductions, and send routine reports to Federal and State tax offices. They hope the computer will do this for them. The business staff also maintains an inventory and keeps the agency's accounts. Each of these operations is routine, but each will need a modular piece of software.

Having completed your initial inquiry, you now summarize your analysis in a single diagram, as shown in Figure 6. This diagram is known as the "system architecture." It defines the main modular elements of the information system.

You now take your diagram to the agency director and explain what you have done. Tactfully you tell the director that the entire system cannot be built all at once and that priorities will have to be set. The agency will have to decide which module should be developed soonest and which can come later. Each module will need to be developed separately and phased in. You explain that the initial focus should not be the agency's forms — the input modules at the top of Figure 6 — but on the specific data needed for the output side — the boxes in the lower half of Figure 6 (see Figure 6).

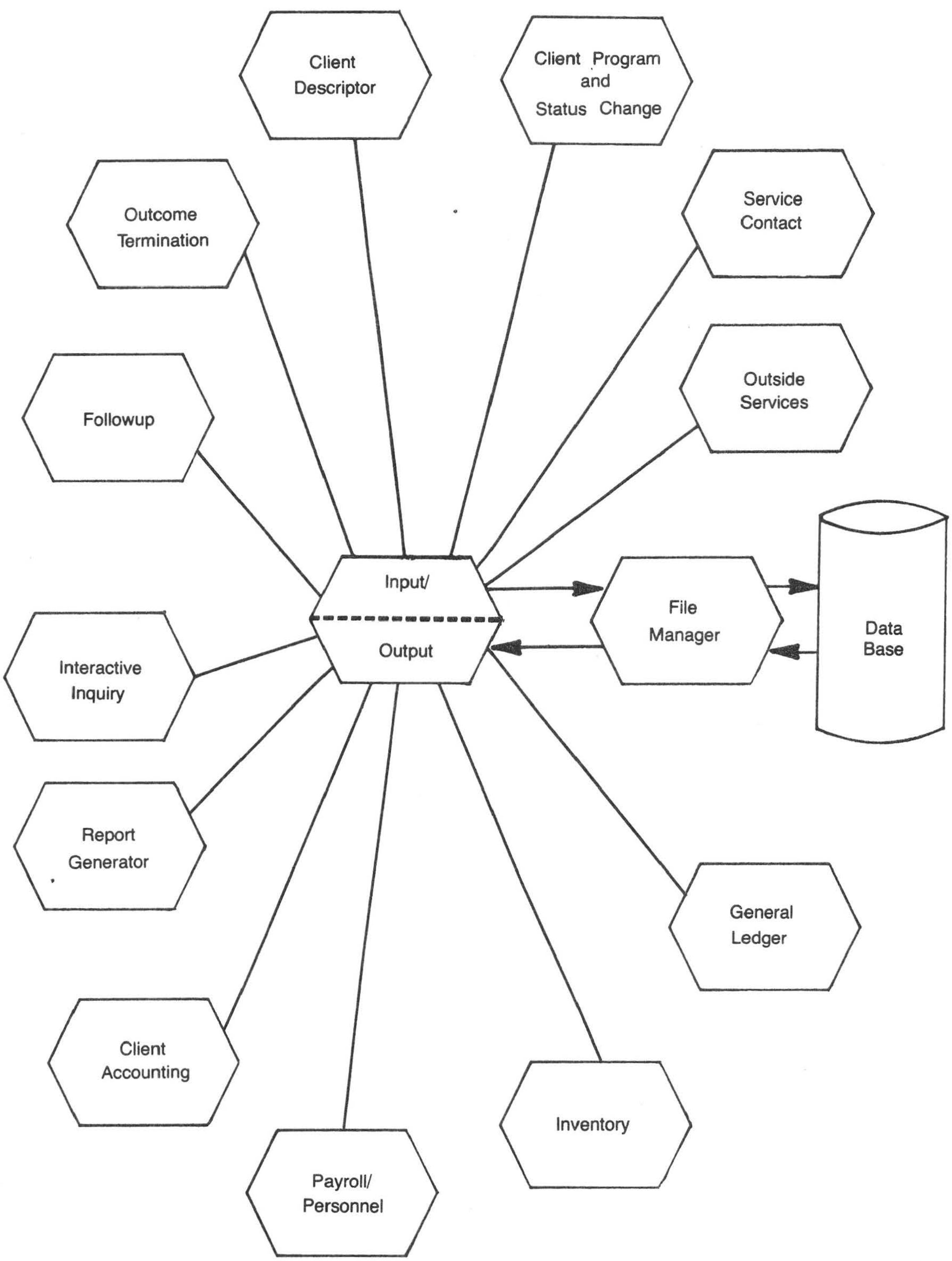
Your first task, however, will be to set up the core modules (also shown in Figure 6): the data base file systems, the file manager, and the input-output software. Having reached agreement on the priorities, you then estimate the time and budget required. This too is reviewed with the director.

So far then, you have created the overall long-range plan to guide the development of the information system. Now you are ready to help the agency decide exactly what is needed for the high priority modules. In short, you are ready for Step 1, as outlined in Chapter Two. You are ready to prepare a set of system specifications for your first module.

After reading this, it may seem that the development of a full-scale information system is always lengthy and expensive, requiring many hours of staff, consultant, and programmer time. Sometimes this is true, but sometimes not. In some circumstances the process can be short and relatively painless. It is short when:

- your agency is small, its operations are not complex, and its director and staff have a very clear idea of their needs and how these needs can be met; or

FIGURE 6 System Architecture for Modular Design



- a similar agency has already developed a system that works, and that meets your agency's needs. You can bootstrap onto other people's efforts; or
- your agency already has a satisfactory manual information system, and you simply want it put on the microcomputer. Here the developmental work has been done, and the rest is relatively easy.

If these conditions are not present, however, an agency may well spend over ten times its hardware costs in developing the system's headware and software.

"Climate" and "Resistance"

So far this chapter has focused on the technical side of systems design. It is equally important to look at the human side of systems design, especially at its organizational dynamics.

Begin with two quotations, one about management and one about staff. The first quotation, about management, is from Wooldridge and London:

> THE FIRST LAW OF COMPUTER FAILURE — *If a company has bad management, a computer will only make it worse*. Or at best, little will be achieved. A typical case is the company in which there is no planning and control, retrospective problemsolving (solving yesterday's problems today and to hell with tomorrow), and management by panic. The workers have a don't care attitude. The political situation is so bad a manager spends 90 percent of this time on covering up his or her mistakes. The last thing you need is better management information from a computer. You need new managers.[6] (p. 24)

This quote describes a particular organizational climate characterized (if not necessarily caused) by poor management. It is found equally often in the public and private sector.

The quotation about staff comes from a report by Boyd et al. on welfare workers' reactions to a very small microcomputer application. They found complaints such as:

(a) the computer ultimately would replace workers and that was why it was being introduced by "administration;"
(b) worker discretion would be eliminated or severely reduced;
(c) clients would be dehumanized;
(d) the project would only help some doctoral students get their dissertation;
(e) the money spent on the project would be better used to increase the adequacy of client benefits; and
(f) the project would take away the already scarce time workers had to help clients.[7]

In addition to those worker's fears...other objections or concerns were expressed:

(g) Even if we believe you, why should we participate? What guarantee do you have that the results of the project will be adopted by the power structure? In the past workers have been asked to participate in helping management solve some problem(s)...but nothing ever comes of it.
(h) "What is administration going to do to reduce its other demands, so that we'll have time to participate in this project?"
(i) "Can we vote to determine whether we'll participate or not? Does every worker in the project have to participate?"

In short, the overall tone of the staff ran from polite but unexcited attentiveness to open hostility.

In his report Boyd describes what is commonly called "resistance" — a semipsychiatric term meaning that people are afraid of computers and their effects. "Resistance" is not unrelated to "organizational climate."[8]

The naive manager assumes that he or she can change a poor organizational climate by firing poor executives and hiring good ones. Sometimes this is true; more often it is not. The naive systems analyst assumes that staff resistance comes from ignorance or stubbornness. Again, this is only sometimes true. Many systems analysts who love computers find resistance deplorable and tend to blame it on poor education, conservatism, or anxiety about change. They believe that resistance is irrational, that after all, to know them is to love them. This belief simply reflects the analyst's bias and glosses over some harsh realities of organizational life.

Look again at the climate Wooldridge and London describe. They cite an organizational setting where the top administrators feel threatened, coerced, unable to determine their own course, deprived of autonomy. This climate is blamed on "poor management" which may be like blaming the victim of an auto accident for not jumping out of the way. The welfare workers described by Boyd reflect similar feelings. They too see the computer as threatening, coercive, depriving them of autonomy. Here again, these complaints may be reflecting a larger organizational climate, since such feelings are most likely to surface in severely troubled agencies. But they also can emerge in agencies that seem, on the surface, placid and well managed.

There is a reason behind staff and management fears, a principle you can call "Taylor's Law." *The computer always threatens to disrupt the power balance within an organization*. This principle is the key to the staffware task. The agency staff fear that the computer will decrease their autonomy and increase the coercive powers of the administrators and supervisors. The administrators and supervisors may welcome greater control over staff, but may fear that information "leaking out" in public will spotlight their own deficiencies. The more shaky, threatening, or threatened the existing power balance, the greater the threat posed by the computer.

In fact, the fears of both management and staff are realistic. Management can easily use the computer to coerce the staff — by minute monitoring of staff time, by questioning the details of program expenses, by cutting off useful services that fall slightly outside the book of regulations. Information "leaked" about program problems may fuel legislative inquiries or place good programs and managers in jeopardy. All agencies have a skeleton or two in their closet — what organization does not? The computer promises "increased accountability — a good thing — but all too often this translates as: "Big Brother is watching you. BEWARE!"

The computer is just a tool. A hammer, like the computer, is just a tool, but you can use it to beat people over the head. There is no reason to beat people over the head with a computer.

How can such problems be overcome? The trick is to design the information system so that the power balance is not disrupted. This requires that all levels of staff have a chance to reflect on the system's implications for themselves and for their work. If aspects of the proposed information system seem threatening or coercive, the staff should be able to negotiate changes in the design. This staff right should be understood and scrupulously adhered to from the beginning, both by staff and by administration. One system analyst has a blanket rule in his contract: previously unavailable data on an individual's performance, workload, or time utilization will be reported only to that worker, and not to his or her supervisor or to higher management. Supervisors will receive only aggregate data about their programs. (Of course the worker is free to share this individual level report with the supervisor.) It is a useful rule, and it reassures the staff that their interests will be protected.

The balance of power is the most potent staffware issue, but not the only one. Some agency resistance also comes from staffers' past experience with computers. Many agency staff people have worked in large social service bureaucracies, and they have seen what happened when a large computer system was installed. Such systems often were pushed on the bureaucracy by outsiders — by the Federal Government wielding carrot and stick, or by State functionaries wielding a budget. The staff saw the computer as a coercive intrusion. The computer was set up by an outside contractor, often months behind schedule. A host of new forms were introduced to feed the machine. Old forms were not discontinued. Paperwork became overwhelming. Worse still, reams of data went into the computer and nothing useful to the line worker ever came out. Instead, mile-high stacks of printouts were produced, a paper glut that no one had time to read or digest. Then some of the data processing was found to be badly in error. The bug was removed, but the past errors had to be corrected by hand, laboriously. A bit later, a legislative committee set up to review the agency's budget requested some additional information. The computer staff explained that the request could not be met with current programs. After a few such episodes, the computer system had won few friends. It seemed to work, however, and people were learning to live with the monster. Then one day the whole system went down, 5,000 checks were not mailed, and the files were erased. Six months passed before the mess was cleaned up.

Such tales of woe are exceptional, but they are reported widely. They fan staff resistance — but needlessly. The good news is that problems of this sort are quite unnecessary, especially in small, less complex agencies. The simpler a system is, the less there is to go wrong.

The bad news, if you want to call it that, is that avoiding such problems requires skilled work. The potential difficulties arise from piecemeal systems design, from inadequate documentation, from sloppy programming, from insensitive staffware, and from too hasty implementation. They also can be the result of inadequate system specification. Remember, paperwork and red tape do not have to increase when a computer is introduced. The line worker does not have to feel victimized by a machine that gives nothing useful back. The decisionmaker does not have to be at the mercy of inflexible programs and programmers. You can do much to guard against such problems. The initial system specification can include a constraint — namely, that the system will require no increase in staff time for paperwork. With good form design, this is generally feasible. It is crucial that time be spent working with agency staff so that the system meets their needs and avoids threatening their autonomy. Such matters should be spelled out in the system specifications.

In Sum

Here are some recommendations for the agency wishing to develop more complex client and management information systems:

1. Check first to see if another comparable agency has developed a similar system you can use as a model. There is no need to reinvent the wheel. Even if the existing system is mounted on a minicomputer or a big main frame machine, you can still use it in designing your microcomputer system.
2. If in fact you do have to start from scratch, figure that you are in for several years of development.
3. Opt for the modular approach to systems design, if at all possible.
4. Prepare the initial system specifications with extreme care, observing the cautions noted in this chapter. Many agencies find some initial consultation helpful in preparing the specifications, but the bulk of the work should be done by agency people.

5. Be alert to the organizational dynamics that attend the effort. Be especially alert to the common managerial desire to extend formal control at the expense of staff autonomy. Remember, as you introduce new managerial controls, you alienate staff. Changes in the power balance must be negotiated and accepted by staff if these changes are to succeed.

Like all general rules, these are not applicable every time, in every situation. Your agency may be the exception — but it is unlikely.

IV. SOFTWARE: CHOOSING IT AND USING IT

Discussions of software are sprinkled throughout the preceding chapters. Before proceeding further, it would be useful to consolidate and summarize certain points that have already been discussed.

1. "Software" is a generic term for all instructions written to guide the computer in its processing of information. Sets of instructions designed to accomplish particular results are called "programs."
2. Most software for microcomputers is written in some version of a programming language called BASIC.
3. For routine and standardized applications, "software packages" can be purchased from a variety of "software vendors." Most such packages are designed to meet business needs. A number of software packages on the market allow you to do word processing with microcomputers.
4. Commercial software packages can be modified to meet specific user needs.
5. Except for the very simplest applications, software development is best left to specialists. Simple programming is a pleasant hobby; complex programming is a demanding profession.
6. Writing new programs is time consuming and expensive. The programs not only have to be written, they have to be debugged and their results validated.
7. If you opt to develop your computer system by the incremental, piecemeal approach, start with the simplest applications first and use commercially available software. The need for consultation should be minimal. In some cases your local computer store owner can mount the system and tell you what you need to know.
8. If you wish to develop a client information system or a management information system, no commercial software packages will meet your needs completely. Neither will commercial software packages fit unchanged into a modular approach to systems development. For such applications an outside systems consultant is essential.

Beyond these matters, you need to know a few other technical points in order to read this chapter:

9. Although most microcomputer software is written in BASIC, different machines use different versions of the language. The BASIC used for Apple computers is different from the BASIC used for the TRS-80, and these are different from the PET BASIC. A program written for one machine may not run on another unless the program is rewritten extensively.
10. Currently, the most commonly used versions of BASIC are TRS-80 I (Levels 1 and 2), DOS, NEWDOS, NEWDOS+ (all for Radio Shack's TRS-80 system); Apple BASIC I and II; CBASIC, and CP/M. Most are machine specific. The bulk of commercial software is written for machines using these languages.

11. Because of this limitation, it makes sense to first see what software packages meet your needs, choose the best among them, and then buy the computer that can use them.

If all this strikes you as a computer-age Tower of Babel, you are not far wrong. Help is on the way, however. Many program packages are sold in several languages to capture the widest market. Multilingual machines are being developed that use programs and chips that allow them to make sense of several computer languages. There is even some movement toward adopting a single computer language for the entire industry. As of this writing CP/M seems the likely candidate. But this will not happen quickly because too many machines, with too many languages, are already in use throughout the United States, and programs will continue to be written for all.

Choosing Single Packages

Assume that you have opted for the incremental approach, and are presently interested in business applications. Given this complexity of the art, how can you find the program packages you need? And, having found them, how can you be sure they work?

The first, most obvious step is to shop around among your local computer stores. The salespeople should be able to demonstrate the most commonly used software available for their machines.

Browse through the computer magazines. Software vendors advertise, and all are willing to send brochures describing their products. They can also tell you who (if anyone) in your locale handles their line.

Check through the software directories. Currently, there are two publishers of comprehensive listings of available software:

- Computermat, Box 1664, Lake Havasu, Arizona 86403
- Micro-Serve, Inc., Box 482, Nyack, New York 10960.

The latter directory has entries from 700 vendors. Unfortunately, the directory listings do not really describe the programs, so you must write the vendors directly.

Having selected a few likely candidates, what then? Good software can be very good indeed; bad software can be disastrous. How do you evaluate it? Unfortunately, Consumers Union offers no testing service for software. So your best source of information is likely to be someone who has already purchased and used the product. An informal telephone call to a past customer can be highly informative.

In evaluating any software package, here are some things to look for:

- Compared to its competitors, does it offer a wider range of useful options? To make their software attractive to the largest market, programmers generally try to include a number of functions within one package. Some of these functions may fit your needs better than others.
- Compared to its competitors, is the documentation comprehensive, clear, and well written? Good documentation for the user should include, at minimum:

  (a) a general narrative describing what the program does, the types of input it uses, and the output it generates;
  (b) samples of printed output;

(c) operator instructions; and
(d) names and descriptions of each data element.

For more technical needs, the documentation should also provide:

(e) a systems flow chart showing the "architecture" of the program;
(f) a listing of procedures, formulae, and decision criteria used in various parts of the program;
(g) logic flow charts of detailed steps carried out by the computer; and
(h) layout of input, output, and storage files.

The first four items are absolutely essential for using the program effectively; the second four are essential if the program needs to be modified.

- Compared to its competitors, does it produce results in a format that is clear, understandable, and consistent with your needs?
- Is there any arrangement for contacting the software producer for advice and help if you have trouble with it?
- Is the software new or has it been around a while? If you are one of the first users of a new software package, you may have the honor of discovering "bugs" that, somehow, were overlooked by the developer. It's an exasperating honor.

Modifying Software

Sometimes even the best available package does not entirely meet your needs. Just a minor bit of modification would be nice. The modification looks simple; it may not be simple. Sometimes in fact modification will be close to impossible.

Often the purchased program will turn out to be written in machine (object) code, and not in BASIC. Machine code is the language the computer itself uses in its internal operations; BASIC is the language it uses to communicate with people. BASIC is patterned after human speech, while machine code is something else again. The computer has to translate all of its BASIC instructions into machine language before it can do anything. When the computer is given a program written in machine language it performs at a higher speed and with more flexibility. This is an advantage, but it has its costs. Programs written in machine language are very difficult to alter. Many highly experienced programmers will not even make the attempt.

The other common problem is less technical. People who sell programs try to make them impossible to copy or alter. They do this in order to frustrate would be pirates, but they also succeed in handicapping legitimate users who need to make changes. A good programmer can usually overcome such problems, but usually only after hours of work and much frustration.

Even without these barriers, software modification can still be difficult. The more complex the program, the greater the difficulty. Even slight modifications can have devastating consequences for other parts of the program. Therefore, programs that have been modified should be tested carefully to validate their performance. And this, too, takes money and time.

The moral, then, is modify if you must; sometimes there is no alternative. But if you can live with the program as it stands, do so.

Software for the Modular Approach

This chapter has been aimed primarily at the user who has routine needs that can be met by standard program packages. In almost every case the user who needs a client information system or a management information system will let the systems analyst worry about software. Still, a few comments may help.

In Figure 6 (page 27), you will find boxes labeled "File Manager," "Input/Output," and "Report Generator." These boxes refer to a special kind of software package called a "Data Manager" or "Data Base Management System." These are highly general programs that set up the "files" on the discs, allow the user to specify what should go into each file (the name of each variable and the number of data characters to be used), and see that the proper information gets put in (or reported out of) the proper slot. In other words, the programs "manage" information storage and retrieval. Another module in the program package allows the user to specify the kind of reports that are wanted and their format. You can, for example, specify which variables you want stored on each client, and the machine does the rest. Or you can specify which client variables you want reported, and out they come. It is a very useful kind of program for client and management information systems.

The good news is that such programs exist and they can dramatically simplify the job of building complex systems by modular design. The bad news is that these programs are all new to the market and vary widely in capability. The first ones to appear were able to store only 20 items of information per client. Those appearing now can do much more. One, written for the TRS-80 Model II, advertises it can store up to 1,200 entries. Others under development offer virtually unlimited capacity. By the time you read this, a number of such software packages should be on the market.

Obsolescence and Confusion

Software, like hardware, is continually changing. New products are introduced every day. For the consumer this situation is highly confusing. No matter what one buys, a better product may appear tomorrow. There is a strong temptation to wait, but the wise buyer resists the temptation. It is better to spend the time now finding the software that meets your needs today. Get it up and running. The software system you buy is likely to be upgraded in a year or two. You can always add new capabilities or switch to the newer and more versatile version when it appears.

V. THE CONSULTANT'S CASEBOOK

If a picture is worth a thousand words, a single case presentation may be worth a thousand pages of exposition. This chapter examines one case of a human service agency that found good use for a microcomputer. The essential facts are real, but some details have been changed, some experiences with other agencies have been mixed in and no names have been revealed. Agencies, like clients, deserve the protection of disguise.

The Ombudsman's Office: Small is Beautiful

It was suggested earlier that the development of a microcomputerized client information system goes most easily when the agency is small, when the staff and director have a very clear notion of what they want, and when a satisfactory manual system is already in place. The Ombudsman's Office presented just this situation.

First, a bit of background. The idea of an "ombudsman" is a foreign importation. Originating in 1809 in Sweden, the term designates a state functionary who investigates citizen complaints of injustice at the hands of public officials. The Scandinavian countries have long had ombudsmen. In recent years the idea has been taken up by at least 18 other nations. In the United States the idea has spread to regional and local levels of public administration and has been adopted in some States by the criminal justice system, universities, police, prisons, and mental health institutions. Essential to the ombudsman's role is detachment from the usual bureaucratic hierarchies and power to investigate complaints with a free hand. The ombudsman is empowered to examine pertinent records, to interview freely at all levels of the pertinent records, to interview freely at all levels of the pertinent bureaucracy, and to make whatever recommendations seem appropriate — about individual actions, administrative procedures, or policy.

In 1973, following a series of scandals in the State mental hospitals, a North-central State set up an ombudsman's office to deal with complaints from or about the State institutions. The new institution's ombudsman reported directly to an advisory board, which in turn was linked to the State legislature. The ombudsman's office consisted of three people: Ron Caplan, the ombudsman; Stu Nesbitt, social worker; and Sue Gordon, secretary. The ombudsman was required to meet periodically with his board and submit an annual report to the legislature. It was this that led, in 1974, to the initial request for consultation.

On the face of it, the problem seemed simple. Each time a complaint was filed, the ombudsman opened a case folder. The details of the subsequent investigation were recorded in narrative fashion. He had also instituted a separate file card noting the date of each contact, so that the secretary could remind him or his assistant of cases that seemed dormant. On a day-to-day basis these procedures worked well enough.

But when the annual report was due, chaos descended. The ombudsman wanted to report how many complaints were opened, how many closed, their disposition, and whether his recommendations had been implemented. The data were in 145 case folders; the information had to be dug out, noted, and compiled by hand. Sometimes the cases were misfiled; sometimes the data were outright missing. All other work came to a halt, and for 2 weeks the office concentrated on the task. During the same period a major crisis occurred at South State Hospital, and the ombudsman found himself working 20 hours a day. It was an experience he vowed not to repeat.

Hence, the consultant was contacted. Could he help the ombudsman's office figure out a more satisfactory way of recording, storing, and analyzing the complaint data, so it was easily available at year's end for the final report?

At the first consultation with Caplan and Nesbitt, additional hopes surfaced. If the information was to be collected, why not use it for other purposes? Suppose, for example, that three times the usual number of complaints had come from South State Hospital. Did this cue the ombudsman to major problems in that setting and the need for special investigation? Suppose that most of the complaints from a single institution clustered around a certain unit or a certain problem. Would this signal a flaw in that institution's procedures or policy? Were the ombudsman's recommendations more apt to be implemented when directed at lower level staff or those higher in the hierarchy? Such information could be valuable, not just for final reports, but for guiding the office's practices and policy.

There were other, more political, possibilities. Information can persuade. What kinds of data could best sell the board and State on the value of the ombudsman's office? Could the data be used to help the ombudsman in his ongoing battles with the then-director of institutions? Also, what kinds of information would be useful in helping the ombudsman staff person for the office? This was a need the ombudsman sorely felt but had to justify.

The staff also had questions about the consultant and his role especially as they began to talk frankly about the agency's problems. Did the consultant see himself as evaluating the program or publishing research about it? And was the consultant really concerned with the program's growth? These are natural concerns and questions, especially when an agency is struggling for survival, when the staff are personally committed to its efforts, and when the consultant is unknown.

The consultant felt the need to clarify his role and service and used the analogy of the lawyer. Like a lawyer, a consultant was a kind of "hired gun" called in by a client to defend client interests. He was, in a sense, an advocate. And, as with a lawyer, all transactions between himself and the client were confidential. No publications, no research reports, no "scientific" self-aggrandizement would be forthcoming.

With this understanding, work progressed. After several more sessions (in which the group explored the possible uses of a data system Nesbitt prepared a memo that summarized, in quite general terms, how he would like to use the information. Caplan added to the memo. The consultant read it, asked questions until he was sure he understood it, and then turned the discussion to the data itself. What specific pieces of information, what data elements, must be captured if these needs were to be met?

What followed was a discussion full of "for instances." Caplan would cite a complaint and the specifics of what happened. Nesbitt would add details and elaborate. Then they would mention another complaint and describe its issues. As the discussion proceeded, the staff became ever more conscious of the complexities of this job. Could such complexity ever be captured by any information system? In the meantime the consultant listened, asked questions occasionally, summarized issues, and attempted to find the order and logic within the ombudsman's operations. The staff, in contrast, seemed ever more doubtful that order and logic existed.

The consultant, however, had an advantage: his perceptions were structured and guided by the kind of roadmap shown in Figure 5 (page 24). The roadmap seemed to fit what he was hearing, except that in this instance the "case" was not a client, it was a complaint lodged with the ombudsman's office. As the consultant listened, he began to outline the flow of "cases" — complaints — through the system:

1. A complaint appears, along with background information.
2. The complaint is evaluated in order to guide the ombudsman to further action.
3. The complaint is either taken on for investigation, deferred, or referred elsewhere.
4. The complaint is treated by contacts with the patient and with others in an investigative process.

5. The complaint is "terminated" by some action or decision.
6. Followup is initiated to see what happened.

The schema seemed to fit fairly well. So as the others around the table grew increasingly overwhelmed with the complexities of their operation, the consultant grew increasingly convinced that the problem was manageable. At the end of the meeting he said as much. The staff seemed astonished. The consultant promised to put down his schema on paper for full discussion at the next meeting. (This is not an unusual experience. Flow charts, simple as they seem, provide a powerful tool for reducing complexity to manageable size. The flow chart illustrated in Figure 5 seems universally applicable as a tool that helps structure thinking about human service agencies and their processes.)

At the next meeting the consultant distributed his memo. It simply spelled out, in greater detail, Steps 1 to 6 as listed above. The staff tried it out immediately with other sample complaints, testing to see how well the schema applied. After a while they agreed that it seemed to provide a meaningful way of ordering their common experiences.

With this established, the consultant raised another issue. Now, he said, they should try to get as specific and inclusive as possible about the information they needed. By what key categories did the ombudsman classify complaints when they were evaluated? What were the key background variables that should be put on the system? What were the key items the staff needed to know about their own interventions? Already the group had made some suggestions, and the consultant cited these. It was a good beginning, he said, but more was required.

The group saw the sense of this and bent to the task. It took 2 months and four consulting sessions before they were through. Provisional sets of categories were devised, discussed, and discarded. Others were tried. Between sessions Caplan and Nesbitt pondered the matter. Eventually the group emerged with a list of data elements that made sense to them, appeared specific enough to be workable, and were clearly pertinent to the ombudsman's needs. (This list, with later additions and modifications, was eventually used by the consultant in designing the computerized client information system put into use several years later. Figure 7 shows its final form.)

FIGURE 7 Sample State Ombudsman's Office File Record

Field

1. Complainant's name
2. Institution or street address
3. City, state, zip
4. Registration number, Department of Institutions
5. Complaint number, ombudsman's office
6. Institution or source of complaint

   Code

   (1) South State Hospital
   (2) North State Hospital
   (3) Central State Hospital
   (4) West State Hospital
   (5) Psychiatric Unit for Prisoners
   (6) State Training School
   (7) Staff
   (8) Volunteer
   (9) Class action
   (10) Other

7. Date complaint received
8. Mode of initiation
   Code
   (1) Letter
   (2) Personal contact
   (3) Phone
9. Mode of first ombudsman response
   Code
   (1) Letter
   (2) Personal contact
   (3) Phone
10. Date of first response
11. Category of main complaint—did it concern care and maintenance?
   Code
   (11) Food
   (12) Medical
   (13) Recordkeeping
   (14) Visiting
   (15) Physical facilities
   (16) Mail
   Security and safety?
   (21) Physical threat
   (22) property loss or damage
   Maintenance of institutional order?
   (31) Disciplinary procedures
   (32) Daily routine
   Rehabilitation activities or procedures?
   (41) Release
   (42) Transfer to other ward or institution
   (43) Counseling/Mental health treatment
   (44) Education/Training/Work details
   (45) Medication
   (51) Internal grievance of staff member
   (52) Complaint against staff person
   Other
   (60) Other
   (70) Mixed complaints
12. Major issues of multiple complaints
   Code
   (11) Care and maintenance
   (12) Security and safety
   (13) Maintenance of institutional order
   (14) Rehabilitation activities or procedures
   (15) Staff problems
   (16) 11 and 12 above
   (17) 11 and 13 above
   (18) 11 and 14 above
   (19) 11 and 15 above
   (20) 12 and 13 above
   (21) 12 and 14 above
   (22) 12 and 15 above
   (23) 13 and 14 above
   (24) 13 and 15 above
   (25) 14 and 15 above
   (26) Three or more major issues in complaint
13. Ombudsman's assessment of issue in complaint

Code
(11) Further explanation needed for complainant
(12) Action taken by institutional staff which was discrepant with regulations
(13) Problem with Department of Institutions *policy*
(14) Problem outside ombudsman's jurisdiction
(15) Problem not conducive to investigation

14. Urgency
Code
(1) Normal, routine intervention required
(2) Crisis, immediate intervention required
(3) Minimal, place on waiting list

15. Highest level of command involved in resolution
Code
(11) Line: clerical, aide level I or II
(12) Line supervisors: aide supervisor level I and II, unit team leader
(13) Staff: nurse, psychologist, MD, social worker, clinical, research, etc.
(14) Middle management: ward director, administrator
(15) Director of State Institution including deputies
(16) Secretary of Department of Institutions including deputies

16. Ombudsman's disposition of complaint
Code
(11) Action recommended—fully accepted
(12) Action recommended—partially accepted
(13) Action recommended—not accepted
(20) Communication facilitated
(30) Observed and monitored situation
(40) Complaint was unfounded
(50) Provided information and referral
(60) Complaint solved prior to intervention
(70) Complaint withdrawn

17. Date case closes

18. Followup ticker note
(1) Followup not needed
(2) Followup to confirm promised action
(3) Followup for some other reason
(4) Case reopened

19. Contact log—who contacted?
(1) Complainant
(2) Department of Institutions personnel
(3) Other

20. Contact log—mode of contact
(1) Letter
(2) Personal
(3) Phone

With the data elements defined at least provisionally, the consultant raised a further question. The categories looked good on paper, he said, but how well did they work in practice? For example, when coding actual cases, could you really tell the highest level of the bureaucracy contacted? Some categories were likely to prove ambiguous or unclear in practice. The consultant suggested the coding needed to be tested and the staff agreed.

The list of data elements was run off on the duplicating machine. Nesbitt used it in the case folder and reported back on the frustrating findings. The list was revised and, when necessary, coding rules were established. From this work, carried out over 2 months, came a set of data elements that seemed unambiguous and workable.

While this was going on, Caplan raised another problem. How could the data be processed once it was collected? Should the coded data be entered on IBM cards to be analyzed by the State's computer people? The ombudsman did not much like that idea. The red tape would be overwhelming, the cooperation minimal, the feedback slow. It made more sense to him to go some other route if possible.

The consultant agreed. With only 143 complaints per year who needed machines? The problem, he suggested, could be handled by edge-punched cards. Neither Caplan nor Nesbitt was familiar with such cards, so the consultant demonstrated their usefulness. He pulled out a pack of commercially available 5 x 8 cards, with numbers along their borders and holes beside each number. He showed how numerical codes that corresponded to the numbers could be entered by marking the number on the border, and how the edge of the card could be clipped so that the hole was broken. And then he showed how a needle, inserted in a single hole of a pack of cards, released those cards that had been clipped. By counting the number of released cards, the ombudsman would know how many cases had been coded with the number corresponding to the clipped hole.

The system would meet the ombudsman's needs. True, it was somewhat tedious, and counting cards by hand was boring. But it clearly was better than what he had. And with 143 cases per year, the procedure was workable.

The ombudsman agreed; the edge-punched cards were adopted. Each data element in the list was given a number corresponding to a number on the margin of the card. An information sheet containing these elements and numbers was run off, to be filled out by the ombudsman and his assistant. The secretary was empowered to scan the information sheet, mark the corresponding numbers on the cards, and clip out the holes on the margin.

When the consultant received the ombudsman's second annual report some months later, he was pleased to see that the system had worked well. The operations of the office were documented, clearly and impressively, and the analysis had pinpointed real problems — not only in the specific institutions but also in departmental policy. These were on their way to resolution.

Five years went by. Two more people joined the ombudsman's staff. The number of complaints directed to his office increased as his availability and effectiveness became known. Now the office was handling about 600 cases yearly. The original information sheet had been revised several times as new data needs emerged. The manual system was increasingly cumbersome; something more was required. Back to the consultant.

By this time microcomputers had become available. Would the ombudsman wish to explore that alternative? The answer: "Maybe." The ombudsman sent two staffers to a nearby State for a seminar on microcomputers. They returned enthusiastic. The ombudsman dropped by a computer store while visiting Metropolis City, 130 miles from Capital City. The salesman told him that what he wanted "couldn't be done." The salesman's jargon put him off; obviously the shop catered mainly to hardware enthusiasts and addicts of electronic games. But cautiously he agreed to go ahead.

First, was a microcomputer system feasible? The consultant knew that the application required a data base management program and the only such program then available was limited to 20 variables or "fields." The program cost $100. Would this modest piece of software fit the ombudsman's needs?

To find out, the consultant took the ombudsman's revised information sheet and listed the variables needed in the system:

Field

1. Complainant's name
2. Institution or street address
3. City, state, zip
4. Registration number, Department of Institutions
5. Complaint number, Ombudsman's Office
6. Code number for institution or source of complaint
7. Date of complaint
8. (No data)
9. (No data)
10. (No data)
11. Nature of main complaint
12. Nature of multiple complaint
13. Ombudsman's assessment of complaint
14. (No data)
15. (No data)
16. Disposition of complaint
17. Date case closed
18. Followup
19. Contact log — who was contacted?
20. Contact log — nature of contact?

He breathed a sigh of relief. The software could accommodate 20 variables; he had 20 variables. The program was feasible.

Two versions of the program had been released: one written for the Apple computer, the other for the TRS-80. The consultant's own system was an Apple, and he liked it. However, he lived in Metropolis City. The ombudsman, on the other hand, was located in Capital City, 130 miles from any service center. If he had equipment trouble, there was no place to turn. This argued for Radio Shack's TRS-80 system, since service was available in Capital City through the local store.

The software required a TRS-80 Level 2 with at least one disc drive. However, two drives — the TRS-80 interface with 16K RAM and the TRS-80 5-inch floppy disc would be more convenient and would reduce the chance of error.

But what about a printer? The consultant foresaw that the ombudsman might want to use the machine as a word processor to turn out routine letters, official reports, and the like. Computer-style dot matrix print lacked the necessary personal or professional touch. As for the statistical reports, their volume hardly justified a high-speed print device. The ombudsman already had an IBM Selectric II in the office. Why not convert this to a printer? When it was not doing computer work — which would be most of the time — it would still serve its original function as a typewriter. The consultant would never recommend the Selectric conversion if a lot of printing was to be done, since the converted typewriter was relatively slow and, with its many moving parts, would not stand up to heavy routine use. But for this application it seemed ideal. For his own word processing he had purchased the Electric Pencil software program and was satisfied with it.

He included one more item, the line-filter voltage regulator, to make sure that variations in the power supply did not cause machine malfunction.

But the consultant was not yet finished. The data base management program could meet most needs, but it had virtually no ability to manipulate data statistically. It could not cross sort the data, or compute averages, or do a chi-square test, or even compute the elapsed time between the opening and closing of a case. The consultant saw that he would have to write a small software program to do the latter computation, but the rest could be handled by a standard statistical program, slightly modified to enable it to draw on the data base files. Other program and modification costs were also figured in.

At his next meeting with the ombudsman, the consultant presented his figures for the total cost of the project, and described in detail what the system could do. The ombudsman noted that his board would have to pass on the request and they might balk. Still, he saw some possibilities. "Let's kick it around when I can get all the staff together," he said.

The consultant repeated his presentation at the staff meeting. He had also prepared a more detailed listing of the variables and codes that would be entered on the machine, drawing from the latest revision of the ombudsman's Complaint Record Form. He passed the listing around (see Figure 7). "You guys will have to revise your current form to accommodate the new codes," he said, "but really it is just a revision of the form you've been using. The secretary will enter the data in the machine, just as she now clips out the cards. Other than that, I don't see that you need to change any procedures. Of course, the secretary and one or two others of you will need to learn how to use the system when it gets up."

The two staff members who had gone to the microcomputer seminar liked the idea of further involvement and saw other possibilities for the machine. Could the system be set up for interactive inquiry, so that client data could be displayed on the screen when needed? "Well," said the consultant, "the data base management program would do some of this, but it could not translate the code numbers back to English text without special programming." Could the system hook into the State's big computer? "Possibly, later," came the answer, "but as of 1978 the equipment is not yet available." The ombudsman had been talking about establishing a separate office at Metropolitan City. If this happened, could a computer there feed into this one? "Not right now," said the consultant, "but by the time you open an office there, it should be feasible." (The consultant was correct. By 1980 all these applications were possible, with the hardware and software readily available.)

Finally, the consultant made his recommendation. "Look," he said, "a lot of stuff will be coming down the pike. There are a lot of things you can do with a microcomputer now, and there will be more. But you are better off moving one step at a time. I'd really advise you to go with your current system — which I admit is minimal — mount it on the machine, and see how it meets your demands. You can add the other stuff later."

"Besides," added the ombudsman, "I don't think I can get much more past my board. In fact, some of this I'll have to disguise in my budget."

And so it was agreed. The actual implementation took quite a while, delayed by the need for budget notifications, by 3-month waits on equipment delivery, by unanticipated program bugs, and by difficulties in scheduling training time for the secretary and staff. Still, the final system seemed to meet the need. At latest contact the ombudsman was satisfied. "We still have some other things we'd like to do with it," he said, "but it will have to wait until State's economy — and our appropriation — improves."

To Point a Moral and Adorn a Tale

The ombudsman's office was small and close-knit; its information needs were modest and precise. Long before the microcomputer was even considered, the main headware tasks had been done — the systems needs had been clarified, the data forms had been designed and tested, the necessary administrative procedures had been put in place. By the time the microcomputers became available, all that remained was to adapt the manual system to the machine.

Yet the process itself would not have been much different had the system been planned for microcomputers from the beginning. There is not that much difference between the headware needed for a manual system and for a microcomputer system. Both require the same steps of systems analysis and design. The smallness of the ombudsman's office, its personalized mode of operation, its flexibility — all of these eased the staffware problems and simplified the consultant's task, but did not change it.

In fact, many small and medium-size agencies that wish to develop a microcomputer-based client information system might follow the same steps with the same satisfactory outcomes. The ombudsman's office is not the only small, close-knit, personalized, flexible agency in existence.

Building a client or management information system for a human service group is a demanding and time-consuming task, as the ombudsman's case makes clear. Yet for many agencies the rewards can be great — and some may be unexpected. The ombudsman obviously ended up with a workable system; he also ended up with a staff who had come to share a common awareness of the agency's mission and functioning. At the end of the system design sessions Nesbitt said, "For the first time, I really think I understand what we are all about." And his comment was not exceptional.

It is likely that the rewards of system development — whether obvious or unexpected — will be greater in the small and medium-size agencies than in the vast Federal and State bureaucracies. The information needs of small agencies are less complex and more manageable; their entire staff can participate in the process of system analysis and design; and their procedures are more flexible and open to change. As such, they are better able to use such information systems to improve their services and operations. With the new capabilities available through the microcomputer, small can indeed be beautiful.

VI. BEYOND ROUTINE: THE 1995 AGENCY

Technological surprise has a way of fading quickly, as yesterday's miracle becomes today's necessity. So, too, expect that microcomputers will seem routine in 15 years, their capabilities embedded in the texture of ordinary life.

In Perspective

It is impossible to predict how the "microcomputer revolution" in human services will occur. Most futuristic scenarios have low validity. However, it is highly probable that something currently beyond our immediate reasoning will occur. Our most dubious prophecies concern implied social and human changes in the resurgent interest in personality evaluation, the broadening of community mental health mandates, the emergence of new computer-linked psychopathologies — all these are only latent possibilities that lie in the lap of the gods. We can be more certain about technological change and its practical implications.

However, the microcomputer revolution may also make possible a transcendence of what agencies currently do. Most human service agencies operate on the basis of common sense, received lore, and practical wisdom. Some evidence suggests that in balance, their well-intentioned actions can do more harm than good. There is no shame in this: for millennia medicine too was a matter of common sense, received lore, and practice wisdom — and for millennia the well-intentioned bleedings and purges did more harm than good. Medicine changed as new technologies and concepts emerged. Human services can change also. With the availability of wide-ranging data from different agencies and settings, the way opens for naturalistic experimentation and solid analysis of various intervention strategies.

There is an old adage that system analysts quote: "There is no right way to do the wrong thing."[9] Beyond its routine and mundane uses, the microcomputer promises to bring to human service practice what the compound microscope brought to medicine — a tool, limited in itself and developed for quite other purposes, but essential to the discovery of the right thing.

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4. Wooldridge, S. and London, K. *The Computer Survival Handbook* (revised ed.) (Ipswich, Mass.: Gambit, 1979).

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6. Wooldridge and London. *The Computer Survival Handbook*.

7. Boyd, L., Miller, L., and Pruger, R. "Equity and Efficiency Project: First Year Report," (Berkeley, Calif.: School of Social Welfare, University of California, 1980).

8. Ibid. p.24.

9. Mao, T. *Quotations from Chairman Mao Tse-tung* (Peking: Foreign Languages Press, 1972).

SUGGESTED READING

Books in the computer field are quickly outdated, and many are highly technical. The following books are reasonably up-to-date, assume no electronics or computer training, and should be excellent guides for new computer program users.

Attkisson, C., Hargreaves, W., and Horowitz, M. (eds.) *Evaluation of Human Service Programs* (New York: Academic Press, 1978).

This book is mainly about program evaluation and needs assessment, but it contains three useful chapters (pages 127-211) on human service information systems. The first two chapters (by Sorensen, Elpers, Feld, and Chapman) are based on work with the Orange County, California Department of Mental Health, but "the experiences are generalizable to nearly any organization where the delivery of human services is the key issue." The third chapter (by Broskowski, Driscoll, and Schulberg) describes an information system developed for a part of Boston's United Way organization, focusing on indirect services.

Bowers, G. and Bowers, M. "Cultivating Client Information Systems," *Human Services Monograph Series*, No. 5, June 1977. Project SHARE, P.O. Box 2309, Rockville, MD 20852. 312 pages.

This useful monograph provides an overview of lessons learned from systems-building projects for human service agencies. Based on 350 reports from different groups, it develops a taxonomy of information systems and their uses, and in Chapter 4 lists prescriptions based on past experience ("Lessons learned ..."). The final section presents abstracts of 214 Project SHARE documents concerned with client information systems.

Chapman, R. *The Design of Management Information Systems for Mental Health Organizations: A Primer*. DHEW Publication No. (ADM) 76-333 (Washington, D.C.: National Institute of Mental Health, U.S. Government Printing Office, 1976). 128 pages.

A guide for mental health personnel who are thinking about or planning an MIS system. This book provides a more detailed expansion of the material covered in the first two chapters cited in the *Evaluation of Human Service Programs*.

Evans, C. *The Micro Millenium* (New York: Viking Press, 1979). $10.95.

Evans, a Britisher, examines the possible short-term, mid-term, and long-term implications of the "microcomputer revolution" for society as a whole. A well-written and thought-provoking contribution.

Garrett, R. *Hospital Computer Systems and Procedures*. (New York: Petrocelli/Charter, 1976). Two volumes. 326 pages (Vol. I).

Garrett follows the footsteps and thinking of a fictional systems analyst as he designs a comprehensive, modular information system for a new general hospital. Very much a how-to-do-it book for systems analysts, these two volumes will probably tell you more about systems design than you want to know. They are, however, well written and surprisingly easy to read. The first volume especially is recommended for browsing.

MICROCOMPUTER APPLICATIONS

Hiltz, S. and Turoff, M. *The Network Nation: Human Communication via Computer*. (Reading, Mass.: Addison-Wesley Publishing, 1978).

A discussion of computerized conferencing methods and their social implications. Among the issues considered are text processing and the automated office, support networks for the aged, and the pooling of data bases for scientific use.

Richardson, D. and Block, H. A. "Developing a Client Based Feedback System: The Mock County Experience," *Human Services Monograph Series*, No. 11, February 1979, Project SHARE, P.O. Box 2309, Rockville, MD 20852. 58 pages.

The authors illustrate their approach to developing a client information system by describing a hypothetical case: a project for the "Mock County" Department of Social Services. Initially they had hoped to describe and critique a real-life example, but a review of 300 possibilities turned up no system which was both client based and supportive of program improvement.

Sidowski, J., Johnson, J., and Williams, T. (eds.). *Technology in Mental Health Care Delivery Systems*. (Norwood, N.J.: Ablex Publishing, 1980).

A series of articles by different authors describes automated testing with the MMPI and the Rorschach, computer interviewing, computer-guided therapeutic training, and several new diagnostic tools based on the computer's ability to analyze complex data (from, for example, speech patterns and physiological recordings) and make actuarial predictions.

Willis, J., Smithy, D., and Hyndman, B. *Peanut Butter and Jelly Guide to Computers* (Portland, Oreg.: Dilithium Press, 1978). $7.95.

An attractively written, down-to-earth description of microcomputer systems: what they are, how they work, and how they can be used. It also provides useful guidelines for equipment purchases.

Wooldridge, S. and London, K. *The Computer Survival Handbook*. (revised ed.) (Ipswich, Mass.: Gambit, 1979).

This book is recommended with reservations. It is a guide for perplexed businesspeople who have "been bent, torn, or mutilated by the computer, or who are afraid they might be." It is mainly oriented toward big business computers. Big business can hire programmers, data processing managers, and the like. Thus the book's advice is not always appropriate for the smaller social agency interested in a microcomputer application. Still, it is packed with common sense, is nicely written, and Osborn's cartoons are worth the price of admission. Its discussion of headware and implementation is especially good, and it is refreshingly honest about the things that can (and often do) go wrong. On the other hand, its discussion of minicomputers and microcomputers is dated and sometimes misleading. Read for insight and enjoyment, but with caution.

Journals

A number of journals on microcomputing have appeared, and more can be expected. They provide useful current information on products, applications, and software. The majority of articles assume some familiarity with computer programming or electronics and tend to stress hobbyist interests. The more venerable journals include:

Byte (published since 1975). A McGraw-Hill publication. 70 Main Street, Peterborough, NH 03458.

Computronics (published since 1979). Box 149, New City, NY 10956.

Creative Computing (published since 1974). Box 789-M, Morristown, NJ 07960.

Kilobaud Microcomputing (published since 1976). Box 997, Farmingdale, NY 11737.

80 Microcomputing (published since 1980). Box 981, Farmingdale, NY 11737.

MICROCOMPUTER

CHARACTERISTICS

JULY 1982

This is a reprint of a publication by
Al Iagnemmo of the Veterans Administration

PREFACE

Information in this document was collected during June 1982. Because of constant changes occuring in the microcomputer industry, this document will be out of date by the time you read it. This document provides only a basic explanation of current microcomputer characteristics. Updated information must be obtained from vendors prior to any evaluation and selection of microcomputer models.

MANAGEMENT SUMMARY

This document provides basic information which can be used to evaluate and select a microcomputer. It contains a description of twelve microcomputer characteristics, including a detailed description of microcomputer software, and a review of twenty-nine models of microcomputers. Summary charts which identify technical information about each model are also included along with a list of considerations used when selecting microcomputers. More than 150 models of microcomputers are presently manufactured. Those evaluated in this document were chosen because they are the principal models marketed in the Washington, Metropolitan area.

The majority of this document is devoted to specific descriptions of the following microcomputer characteristics:

- Manufacturer
- Model
- Microprocessor
- Memory Capacity
- Disk Capacity
- Screen Capacity
- Screen Color
- Keyboard Features
- Ergonomic Features
- Peripheral Capacity
- Software
- Purchase Price

These characteristics, along with other factors, should be carefully considered when selecting a microcomputer. Descriptions and technical information about each of the twenty-nine microcomputer models is a summation of information contained in sales brochures, magazines, and books. More detailed information concerning any of these models can be obtained from vendors.

ACKNOWLEDGEMENT

Some of the information in this document was obtained from reviewing many different books and magazines written about microcomputers. However, the majority of information was gathered from extensive discussions with sales personnel from the following computer stores and vendors:

- Computerland - Bethesda, Maryland
- Computerland - Woodbridge, Virginia
- Computers, Etc. - Silver Spring, Maryland
- Computer Workshop - Rockville, Maryland
- Digital Equipment Corporation - Washington, D.C.
- International Business Machines - Washington, D.C.
- Intuition, Inc. - Arlington, Virginia
- Radio Shack Computer Store - Washington, D.C.
- Star Ware, Inc. - Washington, D.C.
- Virginia Microcomputer Systems, Inc. - Woodbridge, Virginia

Without the benefit of the experience and knowledge of these sales personnel, this document could not have been written. There were many other people who also provided valuable information to help form this document. Information provided by all the sales personnel, consultants, Federal and commercial employees and others is very gratefully appreciated.

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I. INTRODUCTION

There are more than 150 models of microcomputers presently manufactured. Estimates are that microcomputers account for more than 25% of all installed computers in the United States. The tremendous growth of this industry is impressive since microcomputers only became commercially available in 1975 with the introduction of the Altair 8800 microcomputer kit. The following year the Apple computer was developed and marketed. In 1977, the industry grew rapidly with the introduction of the Radio Shack TRS-80 and the Commodore Personal Electronic Translator (PET). Today the industry has grown to more than 50 firms, including major Japanese electronics manufacturers, and more than 200 firms producing peripheral equipment and accessories.

A. Microcomputer Selection

Purchasing a microcomputer can be an easy process; just go to a nearby large retail department store or computer store and buy one. However, to make this process more effective, it is necessary to decide why a microcomputer is needed and what type of microcomputer will best meet those needs. An effective process of selecting a microcomputer is a very difficult task because there are so many combinations of models, peripheral equipment, and software to choose from. The selection process can be divided into at least two phases: 1) Identifying functional requirements and 2) evaluating microcomputer characteristics.

B. Identifying Functional Requirements

An effective plan to select a microcomputer model includes some effort to define the specific functional needs for the equipment. The first step in identifying the functional need is to analyze the present system for processing data. Whether manual or automated, the present system will have certain deficiencies which prevent management from taking timely actions and making effective decisions. After analyzing the present system, it is necessary to define requirements to be met by the proposed system. This involves determining system objectives, functions, boundries for automation, performance constraints, and informational requirements. Tangible and intangible benefits are identified after defining proposed requirements. After the present system has been analyzed, the requirements defined, and the benefits identified, then the next phase of selecting a microcomputer can begin.

C. Evaluating Microcomputer Characteristics

Evaluating microcomputer characteristics is a very difficult part of the process of selecting a specific microcomputer model. It is difficult to determine which characteristics are important and then to determine which models should be evaluated. This document provides information which can be used to evaluate and select a microcomputer. It contains descriptions of twelve microcomputer characteristics, including detailed description of microcomputer software. These characteristics are:

- Manufacturer
- Model
- Microprocessor
- Memory Capacity
- Disk Capacity
- Screen Capacity
- Screen Color
- Keyboard Features
- Ergonomic Features
- Peripheral Capacity
- Software
- Purchase Price

Also, included in this document is a one page list of more than 50 characteristics which should be considered when selecting a specific microcomputer model. In addition to an explanation of microcomputer characteristics, this document also contains a description of twenty-nine models of microcomputers and charts which summarize the technical characteristics of those twenty-nine models.

II. MANUFACTURER

The microcomputer industry consists of more than 50 computer manufacturers, several hundred manufacturers of peripheral equipment and countless software vendors. Reputation and stability of hardware and software vendors is a very important consideration when selecting a microcomputer since new hardware and software vendors are constantly being established and going bankrupt. Sales and service locations, reputation for quality control, warranty periods, and maintenance contracts are other important points to consider when selecting a microcomputer.

A. Sales and Service

Many of the more well established vendors and microcomputer stores are located in most large metropolitan centers in the United States. Some hardware vendors advertise hundreds of locations throughout the country.

However, these are retail sales locations, not service centers. A retail sales store sends damaged microcomputers to a central service center for necessary repairs. This process usually takes several weeks. However, some vendors provide a replacement unit while necessary repairs are being made. Another form of repair service is a third party vendor. Many of the major models of microcomputers are serviced through third party vendors such as TRW, Sorbus, General Electric and others. These third party vendors are distributed throughout the country. For example, TRW is located in more than 100 major metropolitan areas and services many other brands of printers and cathode ray tubes in addition to microcomputer mainframes.

B. Quality Control and Warranty

Most hardware manufacturers have a good reputation for quality control in the production and assembly of microcomputers. However, there are some manufacturers which have a very poor reputation in this area. When selecting a microcomputer, discuss quality control, warranty, and maintenance with several sales offices and users of that equipment. Standard warranty periods for microcomputers are 90 days from purchase by a customer. Some vendors begin the warranty period when the hardware is shipped to the sales office. Therefore, if the sales office has the hardware for two months prior to a sale, then the customer has only one month remaining on the warranty. Most vendors offer annual maintenance contracts which start at the end of the warranty period. These contracts are usually about $300 per year. If the use of the microcomputer will not be closely supervised or extensive problems occured during the warranty period, then a maintenance contract should be purchased.

III. MICROCOMPUTER MODELS

More than 150 models of microcomputer systems are now being marketed. Some manufacturers make only one model and others make several models. Some models come with a keyboard, a video display unit, and a disk drive. However, some models do not include a video display unit or disk drive as part of the standard offering. Printers are optional extras on the majority of microcomputer models. Different models obviously have different capabilities. These differences include: the type of microprocessor, memory capacity, disk capacity, peripheral capacity, size and quality of the video display unit, software availability, and of course price differences. Some microcomputers are designed to be portable, self-contained units with disk drives, small screen video display units, and even small adding machine type printers.

Flexibility and expandability are perhaps the most important characteristics to consider when selecting a specific model of microcomputer. The particular model must be flexible enough to perform mathematical computations, text editing, information retrieval, communications and a variety of other business applications. The ability to expand memory and disk capacity as future needs grow is another aspect to consider when choosing a particular microcomputer. When selecting a specific model, an effort should be made to purchase the most state-of-the-art technology at the least possible cost. Many of the models currently being sold have technology which is five years old. Therefore, an additional consideration is the continued availability of hardware maintenance and software support for models which are not state-of-the-art technology.

IV. MICROPROCESSORS

The main component of any computer is the central processing unit. This unit moves data, performs calculations, controls other units, and executes program instructions. These same functions performed in larger computers have been incorporated into low cost, small units know as microprocessors. More than 30 different types of microprocessors are available for use by microcomputer manufacturers. These microprocessors are either 8 bit, 12 bit, 16 bit, or 32 bit devices. A microprocessor contains all the traditional central processing unit components (i.e., arithmetic and logic unit, accumulator, instruction register, program counter, controller, and working registers) on a single silicon chip smaller than a dime! This small piece of silicon is processed in such a manner as to have imbedded in it several thousand active and passive electronic devices along with all the necessary metallic interconnections.

A. Types of Microprocessors

The power of a microcomputer is determined by its microprocessor and the peripheral equipment connected to it. Most microcomputers contain either 8 bit or 16 bit microprocessors. The most commonly used 8 bit microprocessors are:

- Zilog Z-80 and Z-80A
- MOS Technology 6502 and 6502A
- Motorola 6809

These microprocessors have been in use for approximately five years.

The most commonly used 16 bit microprocessors are:

- Intel 8086
- Intel 8088
- Motorola 68000.

If a microcomputer does not contain one of these microprocessors, then maintenance and software support may be difficult to obtain.

B. <u>16 Bit Microprocessors</u>

A microcomputer with a 16 bit microprocessor is analogous to a car with a bigger engine delivering much more horsepower. Microcomputers with 16 bit microprocessors have the ability to address more memory, execute instructions faster, and provide more flexibility for growth. Some microcomputers, using the power of 16 bit microprocessors and sophisticated software, can accomodate as many as 16 multiple users. Each user can share files, and communicate to one another through the control of a central microcomputer. Sixteen bit microcomputers also have the ability for multitask processing using certain operating systems designed for that purpose. As increases in technology occur, the cost of microprocessors is decreasing. As a result, some microcomputers with 16 bit microprocessors can be purchased for the same, and in some cases, a lower cost than microcomputers with 8 bit microprocessors.

C. Virtual Microprocessors

Virtual microprocessors that can access four or eight million characters of memory have just become available in 16 and 32 bit versions for less than $75 for quantities of 1,000! It is anticipated that virtual operating systems will soon be introduced for these new microprocessors. This will allow desktop microcomputers to access four or eight million characters of main memory at a fraction of the cost of large mainframe computers.

V. MEMORY CAPACITY

One of the most important characteristics to consider when selecting a microcomputer is the memory capacity. Computer manufacturers use the word byte to measure a unit of memory. A byte is a group of binary digits or bits used to represent a character. Some microcomputer models can store up to one million characters or bytes of data in memory. However, the average microcomputer memory capacity is about 64K characters (K = 1,024). Figure 1 and Table 1 show a comparison of memory capacities for the twenty-nine models of microcomputers included in this document.

A. Types of Memory

There are several types of memory used in microcomputers. These are:

- ROM - This is read only memory and contains fixed data or instructions that are permanently installed during the manufacturing process. A user can only read the contents of this type of memory and cannot change it.

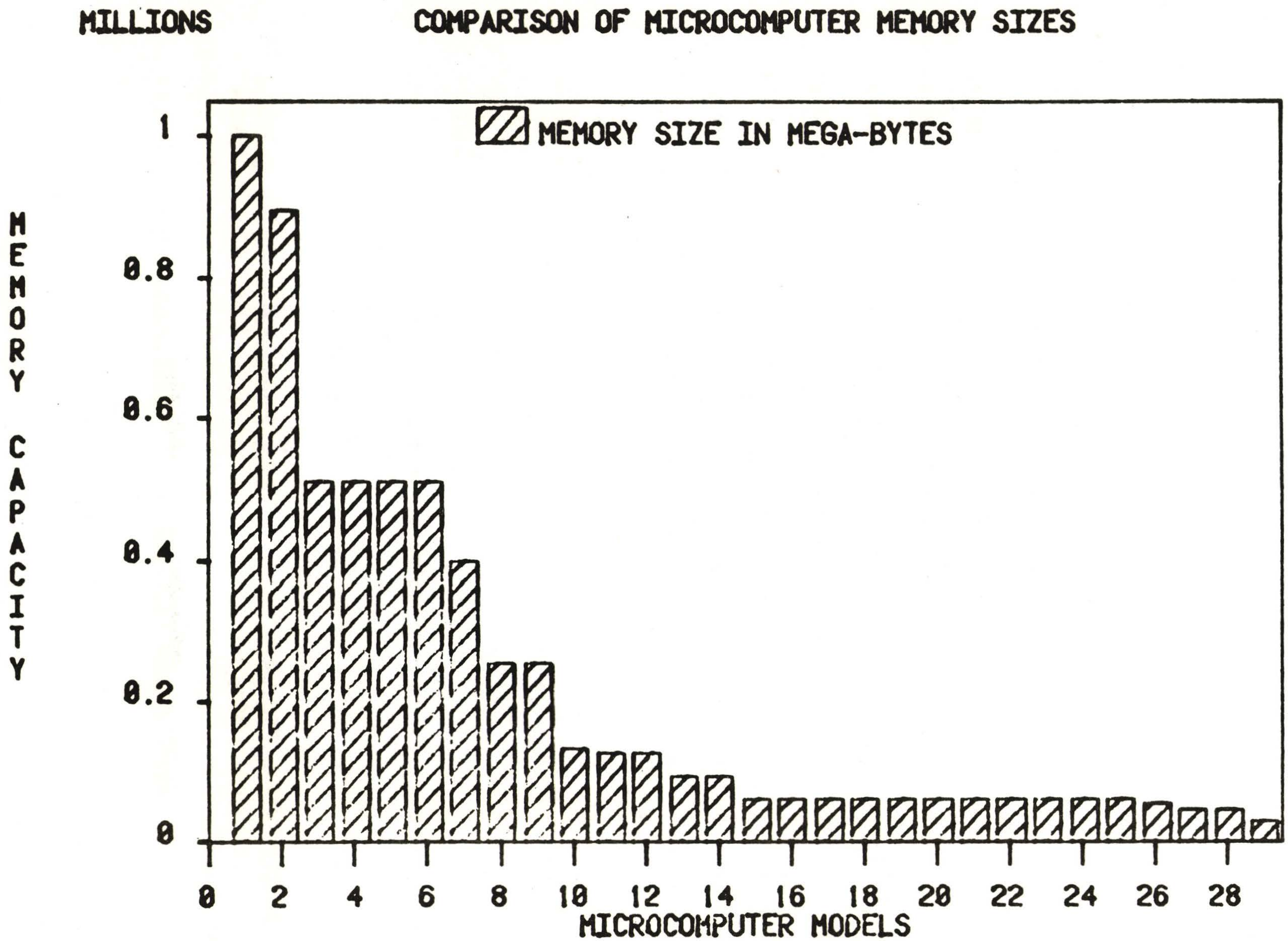

FIGURE 1

(MODEL NUMBERS CONTAINED IN TABLE 1)

TABLE 1

COMPARISON OF MICROCOMPUTER MEMORY SIZES

MODEL NUMBERS	VENDOR/MODEL	MEMORY CAPACITY (Size in K Characters K=1,024)
1	IBM Personal Computer	1,000
2	Victor 9000	896
3	Radio Shack Model 16	512
4	Cromenco System Three	512
5	Cromenco System Two	512
6	Altos ACS 8000	512
7	Dynabyte 5000	400
8	DEC Professional 325	256
9	DEC Rainbow 100	256
10	Commodore SP 9000	134
11	Cromenco System Zero	128
12	Apple III	128
13	DEC DECMATE II	96
14	Commodore CBM 8032B	96
15	Zenith Data System Z-89F	64
16	Zerox 820	64
17	Televideo TS802	64
18	Radio Shack Model II	64
19	Osborne Model I	64
20	North Star Horizon	64
21	Micromation	64
22	Kay Computer KayComp II	64
23	Intertec Superbrain	64
24	Eagle II	64
25	Apple II plus	64
26	Vector Graphics Vector 3	56
27	Radio Shack Model III	48
28	Atari 800	48
29	Commodore Pet 4001	32

- RAM - This is random access memory and it can be read from and written into during normal operation. This type of memory is used in most microcomputers to store the instructions and data for programs currently being run.

- PROM - This is programmable read only memory. It is similar to ROM except that it can be programmed by the user electrically. However, it cannot be changed after creation.

- EPROM - This is erasable programmable read only memory. It is similar to PROM except that it can be erased by ultraviolet light. Therefore, this type of memory can be reprogrammed by the user at will.

Major memory considerations when selecting a microcomputer are the amount of read only memory (ROM) and the amount of random access memory (RAM) which a microcomputer has available. Some microcomputers use ROM to store all or part of the operating system or to store language interpreters or compilers.

B. Available Memory

Random access memory or RAM is the type of memory used for data manipulation and program execution. Memory capacity for microcomputers is usually expressed in the size of RAM. However, this can be a misleading factor when determining the available memory capacity of a microcomputer.

Two different models of microcomputers can have a capacity of 64K characters of RAM. This does not necessarily mean that all 64K characters are available for a user's program or data. Some microcomputers have little or no ROM; therefore, some of the 64K RAM will be used to store the operating system. Consequently, a user may only have about 40K characters of memory available for program use and data manipulation. When selecting a microcomputer it is important that memory capacity consider the amount of RAM along with the amount of ROM. Only in this way can an effective determination be made of the total memory capacity of a microcomputer.

VI. DISK CAPACITY

Disk capacity is also a major consideration when selecting a microcomputer. Disk storage can be on either floppy disks or hard disks. Floppy disks come in two sizes: 5 1/4 inch diameter and 8 inch diameter. Hard disks come in two types: removable and fixed. The amount of information stored on floppy or hard disks varies with the recording density. Some disks record with single density, and others record with double density. Also, some vendors use both sides of the floppy or hard disk for recording information and some only record on one side. Figure 2 and Table 2 show a comparison of disk capacities for the twenty-nine models of microcomputers included in this document.

A. Floppy Disks

When selecting a microcomputer it is important to consider whether 5 1/4 inch or 8 inch diameter floppy disks are used. The two are not interchangeable. As a matter of fact, 5 1/4 inch floppies are generally

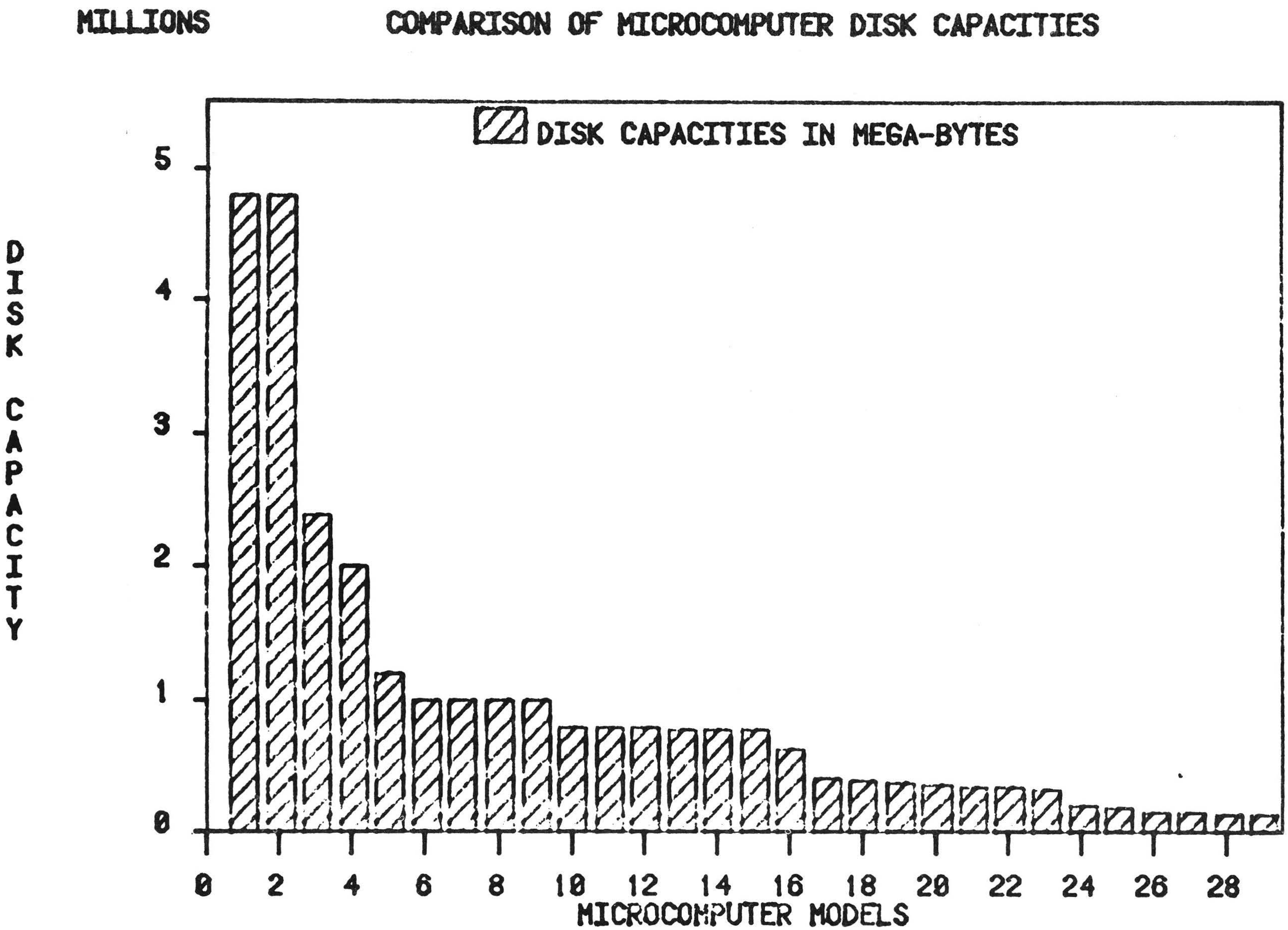

FIGURE 2

(MODEL NUMBERS CONTAINED IN TABLE 2)

TABLE 2

COMPARISON OF MICROCOMPUTER DISK CAPACITY

MODEL NUMBERS	VENDOR/MODEL	DISK CAPACITY (Size in K Characters K=1,024)
1	Altos ACS 8000	4,800
2	Cromenco System Three	4,800
3	Radio Shack Model 16	2,400
4	Micromation Mariner	2,000
5	Victor 9000	1,200
6	Televideo TS 802	1,000
7	Dynabyte 5000	1,000
8	Commodore SP 9000	1,000
9	Commodore 8032B	1,000
10	DEC Professional 325	800
11	DEC DECMATE II	800
12	DEC Rainbow 100	800
13	Eagle II	780
14	Cromenco System Two	780
15	Cromenco System Zero	780
16	Vector Graphics Vector 3	630
17	Radio Shack Model II	415
18	Kay Computer KayComp II	400
19	Radio Shack Model III	368
20	North Star Horizon	360
21	Intertec Superbrain	350
22	Commodore Pet 4001	340
23	IBM Personal Computer	320
24	Osborne Model I	200
25	Xerox 820	184
26	Atari 800	163
27	Zenith Data System Z-89F	160
28	Apple II Plus	140
29	Apple III	140

not interchangeable from one microcomputer to another. Most microcomputers use soft sectored 5 1/4 inch floppies; however, some use hard sectored floppies. The characteristics of each present physical differences which inhibit compatibility. Software differences also inhibit compatibility. As a result of operating system and software formatting differences two diskettes will not be compatible even though both may have the same physical characteristics. Floppy disks are limited by the amount of data storage and the speed of access to the data.

B. Hard Disks

If fast, on-line access to large quantities of data is necessary, then a hard disk should be considered for a microcomputer. Two basic types of hard disks are removable cartridge disks and Winchester disks. Removable cartridge disks are sealed in a special container which can be removed from the drive. This provides for storage of additional data. Winchester disks on the other hand, have a rigid disk permanently sealed inside the drive and cannot be removed. Winchester disks are much cheaper than removable cartidge disks and are the most popular type of hard disks used for microcomputers. As a result of recent advances in technology it is now possible to store more than 40 million characters of data on 5 1/4 inch Winchester style hard disks.

VII. SCREEN CAPACITY

Most video display tubes connected to a microcomputer are a standard size. They can display 80 characters on each row and 24 or 25 rows of information on the screen. However, some display tubes can only display

40 characters on each row. This makes it difficult to read complete lines of text or complete lines of computer programs. If a microcomputer is used for programming and word processing a screen capable of displaying 80 characters on each row is necessary.

A. Lower Case Display

If a microcomputer is used for word processing a video display tube must be able to display lower case letters. When selecting a microcomputer, ensure that lower case letters are displayed with descenders. Without this quality, certain letters (i.e., g, j, p, q, y) will not have part of the letter descending below the normal line of text.

B. Screen Resolution

Screen resolution is an additional concern when selecting a microcomputer. Characters displayed on a screen are composed of tiny dots in a matrix format. Standard character size is a 5 x 7 dot matrix. Screens with a higher resolution have characters composed of a 9 x 14 dot matrix. A higher resolution screen is much easier to view for long periods of time. Characters on a high resolution screen also have a much better quality when printed.

VIII. SCREEN COLOR

Color of characters displayed on a screen is another important characteristic to consider when selecting a microcomputer. Most microcomputers display white characters on a black background. Better quality screens display green phosphor characters which are easier to view for extended periods of time.

A. Special Features

Video display tubes should have a non-glare coating on the surface to reduce reflections, enhance character contrast and improve overall readability. Independent adjustments should be available for brightness of characters and background as well as screen contrast. A split screen capability allows portions of each of the 24 lines to be scrolled separately for menu selections, messages and prompts. Full and split screen, as well as horizontal and vertical scrolling should be available for convenient, comfortable viewing of information. High quality video display tubes may have the ability to add emphasis to sections of text by double height lines and double width characters as well as allowing any characters to be highlighted with bold, blinking, or reverse video features.

B. Color Graphics

If a microcomputer video display tube can display color then it is necessary to consider the color graphics resolution. Resolution of graphics screens is determined by the number of pixels or picture elements which can be displayed. A pixel is a definable location that is used to form images on the display screen. For color graphics displays, screens with more pixels generally provide a higher resolution. High resolution color graphics screens contain 800 pixels by 240 pixels and low resolution screens contain 320 pixels by 240 pixels.

IX. KEYBOARD FEATURES

Data and programs are entered into a microcomputer with a keyboard. Because the keyboard serves as the direct link to the microcomputer, its design and quality are very important. The difference between an adequate keyboard and a superior one depends on how well it has been manufactured and human engineered.

As a minimum, a keyboard should have a standard typewriter layout with upper and lower case letters. Keys should be contoured and textured with matte finish and dark-on-light legends to reduce typing errors and glare from surrounding light. High quality keyboards include an automatic repeat feature for all alphanumeric keys. Keyboards should also have a numeric keypad which can be used to input numbers like a calculator. Some additional keys must be included to control moving the cursor and text on the display screen.

Another very important function of a keyboard is known as rollover. This function allows the keyboard to transmit the last key pressed down, when two or more keys are pressed down, even if other keys are not released. Fast operators continuously overlap keystrokes and need the rollover function. Various command and function keys are also included in a high quality keyboard. These keys can be either firmware or software driven. Software driven keys can be defined to perform a specific operation or set of operations in a program.

X. ERGONOMIC FEATURES

Ergonomics is the science of human engineering which combines the study of human-body mechanics and physical limitations with industrial psychology. Consideration of human engineering in a microcomputer system contributes to increasing operator efficiency as well as decreasing operator fatigue and decreasing errors.

Ergonomic features are mainly evident in keyboards and video display tubes. For maximum human engineering consideration, the keyboard should be the optimum height for efficient typing. Its shape, feel, typing angle, and layout should be comfortable and logical. Keyboards should have audio and tactile feedback to increase operator awareness of what the microcomputer is doing without having to always look. A keyboard may be attached to the display screen by a coiled cord that allows it to be moved to a comfortable position for working. For optimum viewing ease, the display screen should swivel to the left and right and tilt forward and backward. Ergonomically designed display screens have green phosphor characters, non glare screens and, have a pleasant appearance.

XI. PERIPHERAL CAPACITY

When selecting a microcomputer, an extremely important characteristic is the capacity to attach multiple peripheral devices such as printers, modems, additional memory and disk drives, and other special equipment. These devices are attached to either an internal system bus or an input/output bus. A bus is a group of parallel electrical connections that carry signals between different microcomputer components or devices.

A. Internal System Bus

An internal system bus transmits all types of information among the various components within the microcomputer. The internal system bus used in most microcomputers is the IEEE standard S100 bus. An S100 bus contains 100 pin connections to plug circuit cards into for transmitting information between the microprocessor and memory, or the microprocessor and peripheral interfaces, or between memory and peripheral interfaces. The type of internal system bus used will determine the flexibility for adding internal circuit cards and expanding the capabilities of a microcomputer.

B. Input/Output Bus

Input/output busses are used to transmit information between two microcomputers or between a microcomputer and certain devices (e.g., printers). Two of the most commonly used standard I/O busses are the RS232C and IEEE-488. The RS232C serial interface bus is used to connect microcomputers to printers, terminals, and some low speed peripherals. The RS232C interface costs much less to implement than the IEEE-488 bus. However, the IEEE-488 bus allows a wider range of peripheral devices to be connected to a microcomputer. When considering peripheral capacity it is important to choose a microcomputer that uses either the RS232C or the IEEE-488 bus to communicate with devices beyond the microcomputer itself. This will ensure some degree of expansion for the particular model chosen.

XII. MICROCOMPUTER SOFTWARE

The choice of software is the single most important factor to consider when selecting a microcomputer. The cost of the operating system and application programs is not a large expense. These products usually cost several hundred dollars each. Since hardware cost is only several thousand dollars, the largest cost associated with a microcomputer is the investment in user written software. Therefore, it is very important that careful consideration is given to selecting the operating system, application programs, and languages used by a microcomputer. The remainder of this section provides a detailed description of microcomputer operating systems, application programs, and programming languages.

A. Eight-bit Operating Systems

The most commonly used generic operating systems for 8-bit microcomputers are:

- CP/M 80 (Version 2.2)
- MP/M
- OASIS

CP/M (Control Program for Microcomputers) is marketed by Digital Research, Inc. This operating system was developed by Gary Killdall, a Naval Officer at the Naval Post Graduate School in Monterey, California. After an unsuccessful attempt to sell CP/M to Intel, Gary started Digital Research and sold hundreds of thousands of copies for $150.

As a result of its wide use, CP/M has become the de facto industry standard operating system for 8-bit microcomputers. Many models of microcomputers use CP/M as their standard operating systems. Models not offering CP/M as their operating system, can have an inexpensive hardware modification to allow CP/M to operate. Hardware modifications are even available to allow CP/M to operate on 16 bit microcomputers.

A multiuser version of CP/M, known as MP/M, was also developed by Digital Research, Inc. This operating system controls several microcomputers which are connected for purposes of resource and data sharing and communications. OASIS, developed by Phase I Systems, is another popular multiuser operating system. OASIS, which is a data base management operating system, has a version written for 16 bit microcomputers.

Some major microcomputer manufacturers have their own operating systems. For example, Apple computers use Apple DOS and Radio Shack computers use TRSDOS. Application programs and languages written for one operating systems will not work with a different operating system. Many of the more popular models of microcomputers, such as Apple and Radio Shack, have application programs and languages written for those proprietary operating systems.

UMTA/FHWA Technical Note
The UCSD P-System operates on both 8 bit and 16 bit computers. It is more widely used than just in educational institutions.

B. <u>Sixteen-bit Operating Systems</u>

The most commonly used generic operating systems for 16 bit microcomputers are:

- CP/M86
- SB/86
- P-System

CP/M86, written by Digital Research Inc., is a 16 bit version of CP/M80. This is not as widely used for 16 bit microcomputers as CP/M80 is for 8 bit microcomputers. In fact, only about 15% of 16 bit packaged application programs are written for CP/M86. A variation of this operating system, known as Concurrent CP/M86, provides multitasking for a single user.

SB/86, written by Seatle Computer Inc., is another 16 bit operating system. This operating system has been rewritten by Microsoft, Inc. to MS/DOS and IBM/DOS. Eighty-five percent of 16 bit packaged application programs are written for the SB/86 operating systems. Usually these packages will run with MS/DOS and IBM/DOS. Because of the recent introduction of 16 bit operating systems a de facto standard has not yet developed. However, it appears that SB/86 will be that standard. Lifeboat Inc., which is primarily responsible for the wide distribution of CP/M80, has chosen to distribute SB/86 rather than CP/M86 for 16 bit microcomputers.

Another 16 bit operating system is the UCSD P-System. Developed by the University of California at San Diego, this System is primarily used in educational institutions and is classified as an Interpretive Emulator.

The special feature of this system is that it allows application programs written on one model of hardware to be run on a different model of hardware. This portability can only be obtained by writing the application programs in P-System versions of FORTRAN, PASCAL, BASIC, and COBOL. These programs, when compiled by the P-System operating system, generate P-Code which can run on any other hardware which has the P-System installed.

Two other operating systems which can be used on 16 bit microcomputers are UNIX and PICK. UNIX, developed by Bell Laboratories, is a very sophisticated operating system and not user friendly. UNIX works very well on a variety of minicomputers and large mainframes. Versions of UNIX, and look alikes such as QUNIX, have been written for some 16 bit microcomputers. Another 16 bit operating system, PICK was developed by Dick Pick of Pick and Associates in Irvine, California. This operating system works on a variety of 16 bit minicomputers and will soon have versions available for the more popular 16 bit microcomputers.

C. Application Programs

The availability of packaged application programs is an important consideration when selecting a microcomputer. There is a tremendous number of application programs currently available for the more popular microcomputer models. These commercially available packages generally fall into the following categories:

- Accounting
- Communications
- Data Base Mangement Systems
- Mailing Lists
- Planning
- Sort/Merge

- Electronic Spreadsheets
- Graphics
- Instructional Aids
- Inventory Management
- Spelling Aids
- Statistical
- Time Management
- Word Processing

In each of these categories there are many application programs available. The cost for most of these programs is between $200-400.

D. Programming Languages

The most commonly used programming language for microcomputers is BASIC (Beginners All Purpose Symbolic Instruction Code). There are versions of this language written for almost every operating system and microcomputer model. The most popular versions are CBASIC 2 and Microsoft BASIC or MBASIC. BASIC comes in either an interpretor or a compiler version. The interpretor version will provide faster program development whereas the compiler version will provide faster program execution. Some vendors include a version of BASIC in the read only memory of the microcomputer.

Pascal is another language very widely used for microcomputers. The most popular version is UCSD PASCAL, developed by the University of California in San Diego. It is expected during the next several years that PASCAL usage may become more popular than BASIC.

Some of the other programming languages used for microcomputers are:

- ADA
- ALGOL
- APL
- "C"
- COBOL
- FORTH
- FORTRAN
- JANUS
- LISP
- OMNI
- PL/1
- THREAD

Different versions of these languages are available for different operating systems and different models of microcomputers. It is important when selecting a microcomputer to consider which language versions will operate on a specific model with a specific operating system.

XIII. PURCHASE PRICE

Purchase price is an important characteristic which should be considered when selecting a microcomputer. Because of the low cost of hardware and software, purchase price is usually not a major consideration when selecting a microcomputer. Other characteristics, previously described in this document, should be evaluated prior to considering the purchase price.

When purchase prices is evaluated, it is necessary to determine exactly which components are included in the price. Printers and software are usually not included in the purchase price therefore, these items need to be added to the price for a minimum configuration. To arrive at a total purchase price, it is necessary to include all options, cables, supplies, interfaces, languages, operating systems, application programs, manuals and maintenance contracts. There is a wide range of purchase prices for each microcomputer model. Figure 3 and Table 3 illustrate this wide range of purchase prices.

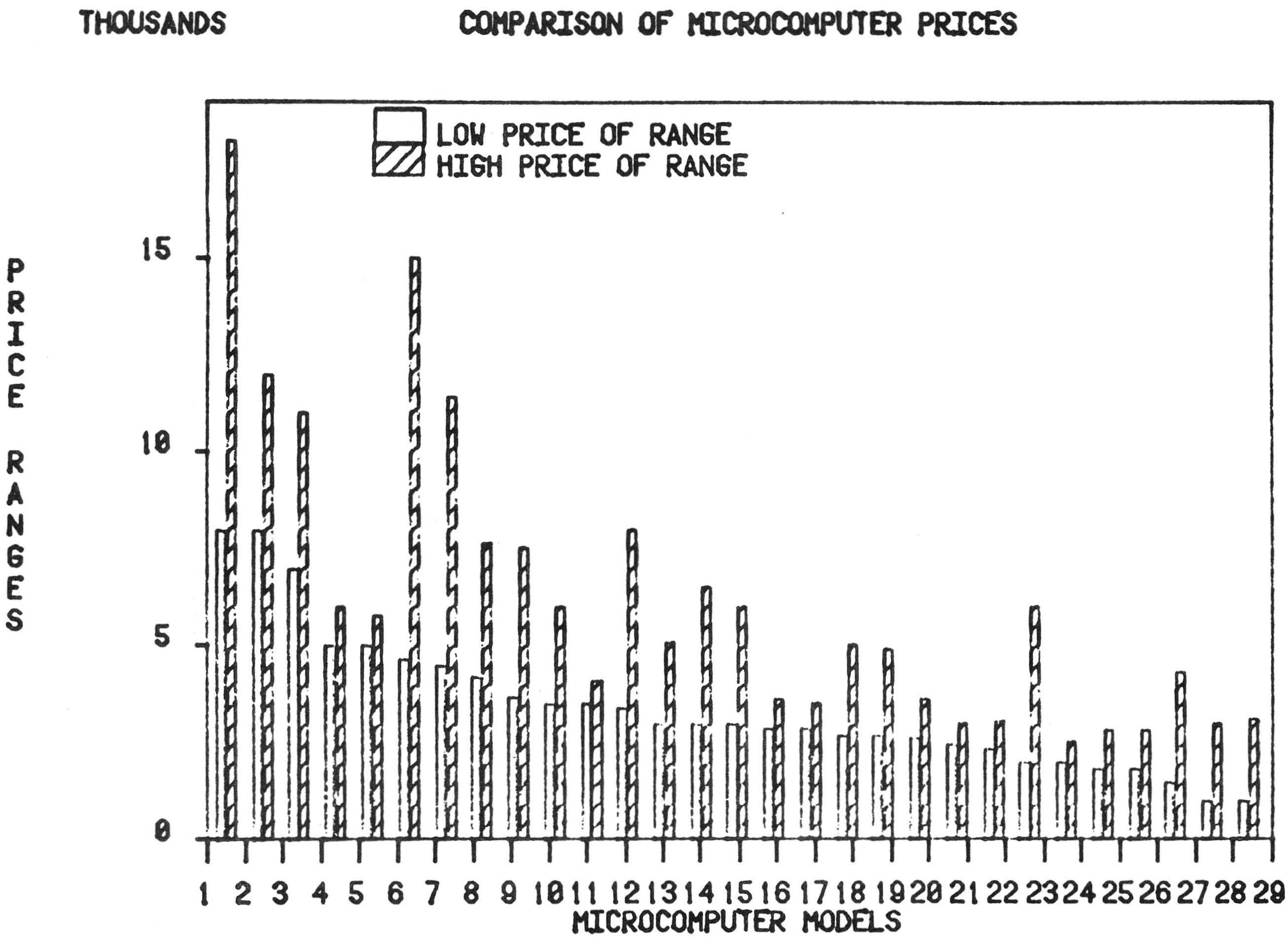

FIGURE 3

(MODEL NUMBERS ARE CONTAINED IN TABLE 3)

TABLE 3

COMPARISON OF MICROCOMPUTER PURCHASE PRICES

MODEL NUMBERS	VENDOR/MODEL	PURCHASE PRICE (DOLLARS)
1	Cromenco System Three	8,000-18,000
2	Altos ACS 8000	8,000-12,000
3	Dynabyte 5000	7,000-11,000
4	Victor 9000	5,000-6,000
5	Radio Shack Model 16	4,999-5,798
6	Cromenco System II	4,695-15,000
7	Micromation Mariner	4,500-11,400
8	North Star Horizon	4,195-7,610
9	Vector Graphics Vector 3	3,695-7,500
10	Radio Shack Model II	3,500-6,000
11	Apple III	3,495-4,070
12	DEC Professional 325	3,375-8,000
13	DEC DECMATE II	3,000-5,100
14	Xerox 820	2,995-6,500
15	Cromenco System Zero	2,995-6,000
16	Televideo TS802	2,900-3,600
17	Zenith Data System Z-89F	2,900-3,500
18	Eagle II	2,695-4,995
19	DEC Rainbow 100	2,675-4,900
20	Apple II Plus	2,615-3,610
21	IBM Personal Computer	2,490-2,980
22	Intertec Superbrain	2,349-3,053
23	Commodore SP 9000	1,995-6,000
24	Radio Shack Model III	1,995-2,495
25	Osborne Model I	1,795-2,795
26	Kay Computer KayComp II	1,795-2,795
27	Commodore 8032B	1,495-4,300
28	Atari 800	1,000-3,000
29	Commodore Pet 4001	995-3,100

XIV. OTHER CHARACTERISTICS

In addition to the twelve characteristics previously described, an evaluation and selection of microcomputers should consider:

- Printers
- Processing Speed
- Maintenance
- Training
- Documentation

These characteristics may help to determine the differences among several models which are alike in other characteristics.

A. Printers

There are more than 100 models of printers and more than 20 models of plotters which can be used with microcomputers. Prices range from $500 to $3,000 and print speeds range from 15 characters per second to more than 300 characters per second. Two basic types of printers used for microcomputers are dot matrix and daisy wheel. Daisy wheel printers are usually used for letter quality printing and dot matrix printers are used for draft and program printing. Standard dot matrix printers use a 5 X 7 dot matrix; higher quality printers use a 9 X 14 dot matrix. Most printers use 80 column paper and are "bidirectional" and "logic seeking." Logic seeking means that a printer figures out the most efficient way to print a new line based on where it stopped printing the previous one. On some printers tractor feeds for computer paper and automatic sheet feeds are extra attachments. Color and graphics options can be added to some printers for as little as $500.

B. Processing Speed

Another characteristic to consider is the processing speed of a microcomputer. One indication of processing speed is clock frequency. This is measured in millions of cycles per second or megahertz (MHz). Most of the 29 models included in this document have a 4 MHz clock frequency. Some of the older models have a 2 MHz clock frequency and some of the newer 16 bit models have a clock frequency greater than 4 MHz.

Another method for determining processing speeds is to run a series of programs on each model being evaluated. The time required to execute each program can be compared between all models being evaluated. Figure 4 and Table 4 is an example of a comparison of 20 different microcomputer models. Each model ran a seven line BASIC program which did 2,000 additions and 1,000 multiplications. The time required to run this program on each model was recorded and tabulated for comparison. Some of the reasons for the differences in processing speeds are:

- Clock frequency
- Microcomputer instruction set
- Microcomputer word length
- Use of an interpretor or compiler for BASIC
- Degree of sophistication of the interpretor or compiler

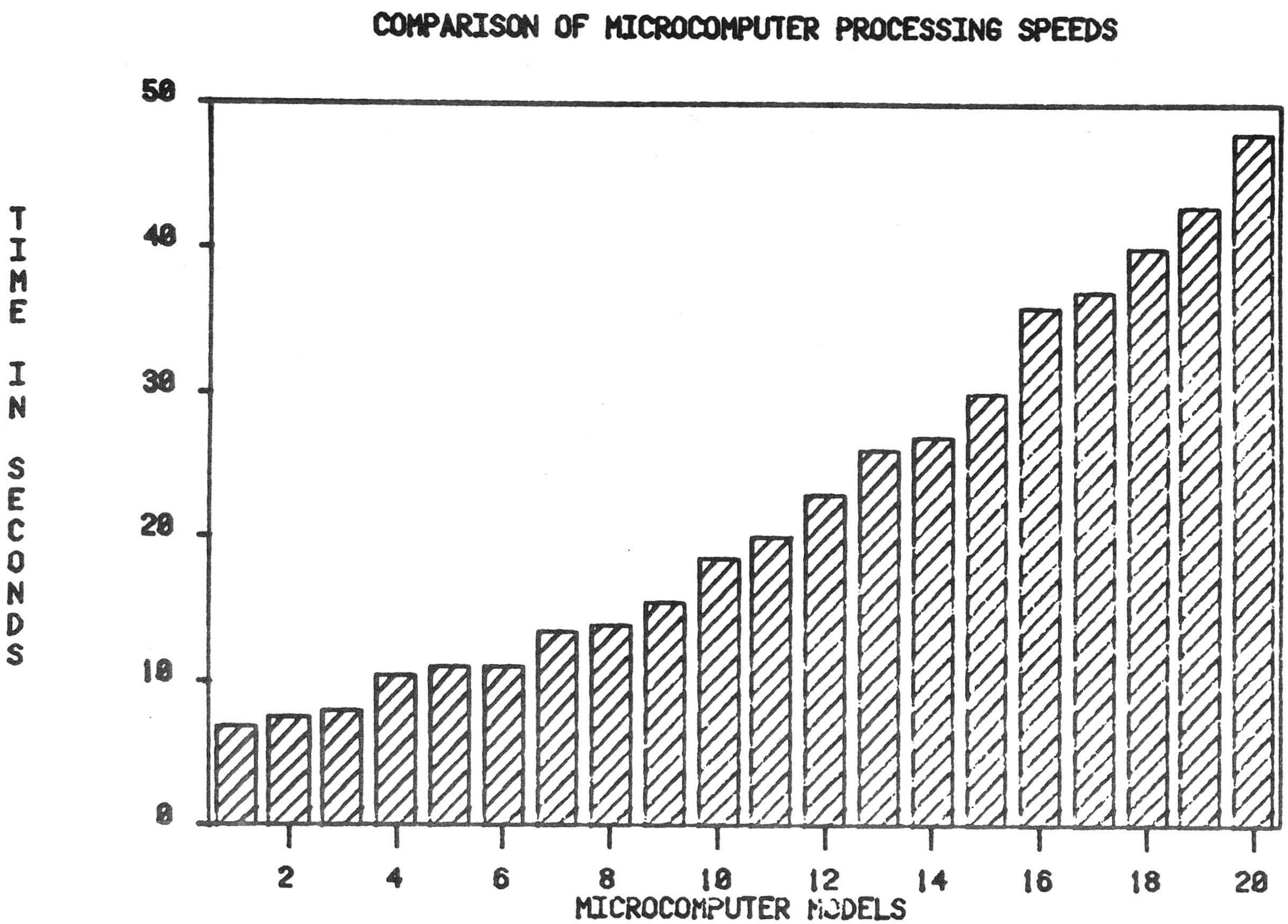

FIGURE 4

(MODEL NUMBERS ARE CONTAINED IN TABLE 4)

TABLE 4

COMPARISON OF PROCESSING SPEEDS

Model Numbers	Time (Seconds)	Manufacturer/Model	Microprocessor
1.	7	Vector Graphics (Vector 3)	Zilog Z-80
2.	7.5	IBM Personal Computer	Intel 8088
3.	8	Osborne (M Basic)	Zilog Z-80
4.	10.5	Cromenco Z-2	Zilog Z-80
5.	11	Hewlett Packard HP85	Zilog Z-80
6.	11	NEC PC-8001A	Zilog Z-80
7.	13.5	Sinclair ZX81 (Fast Mode)	Zilog Z-80
8.	14	Osborne (C Basic)	Zilog Z-80
9.	15.5	Atari 400 (or 800)	MOS Technology 6502
10.	18.5	Texas Instruments TI 99/4A	TMS9900
11.	20	Apple III (Business Basic)	MOS Technology 6502A
12.	23	Radio Shack TRS-80 Model II	Zilog Z-80A
13.	26	Apple II	MOS Technology 6502
14.	27	Commondore VIC 20	MOS Technology 6502
15.	30	Commondore PET	MOS Technology 6502
16.	36	Altair 8800 (3.1 Basic)	Intel 8080
17.	37	Radio Shack Color Computer	Motorola 6809
18.	40	Altair 8800 (E Basic)	Intel 8080
19.	43	Radio Shack TRS-80 Model III	Zilog Z-80A
20.	48	Radio Shack TRS-80 Model I	Zilog Z-80

Some microcomputers perform addition faster than other models but may perform subtractions slower. Therefore, to obtain a correct measure of processing speed it is necessary to run several different types of programs on each model being evaluated.

C. Maintenance

When evaluating and selecting a microcomputer another factor to consider is maintenance availability. Determine the cost of annual maintenance, if available, who will do the maintenance, and where the maintenance will be done. Most vendors require the damaged microcomputer to be brought to their service facility. However, some vendors will arrange on-site maintenance or will bring a replacement unit to your office while repairs are being made.

Maintenance problems with microcomputers are usually mechanical. Problems occur as a result of something being dropped or spilled on the keyboard, a malfunction occuring in the printer, a disk head crash, or a power overload. Microcomputers are fragile and should be handled more carefully than an electric typewriter or pencil sharpener. Some problems can be prevented by periodically cleaning all the equipment, including disk read/write heads. Some types of floppy disks do not have reinforced centers and wear out, thus causing read/write problems. Reinforcing rings can be purchased for these types of floppy disks. Some models of microcomputers have built-in protection against power surges. An inexpensive voltage surge protector should be purchased for models which do not have this built-in protection. A voltage surge protector should protect the system from line noise, spikes, surges and dips and keep the system operational between 95 and 140 volts.

D. Training and Documentation

Microcomputers are designed to be user friendly with little or no training required for their operation. However, some vendors do provide training in BASIC programming and operating system usage. The availability of this type of training can be an important factor with the implementation and acceptance of microcomputers into a business organization. Clear, well written documentation can also be an important factor in gaining acceptance of this new tool into any business organization. Operational and programming documentation ranges from excellent to useless for different models of microcomputers. Because of their importance, training and documentation should be carefully considered when evaluating and selecting microcomputers.

UMTA/FHWA Technical Note
Reference is to first paragraph, page 37. Apple II Plus has extensive business and transportation software that is not "game oriented". It is widely used by transportation agencies.

XV. MICROCOMPUTER SELECTION CONSIDERATIONS

The following list contains factors which should be considered when evaluating and selecting microcomputers.

- Manufacturer reputation
- Sales and Service locations
- Quality control reputation
- Warranty periods
- Age of equipment
- Multiuser system
- Portable model
- Type of 8 bit processor
- Type of 16 bit processor
- Total memory capacity
- RAM capacity
- ROM capacity
- Memory expansion ability
- Total disk capacity
- Floppy size
- One or two side recording
- Single or double density
- Hard or soft sectored
- One or two drives
- Hard disk availability
- Disk expansion ability
- Screen capacity
- Upper and lower case
- Descenders for lower case
- Screen resolution
- Dot matrix size
- Screen color
- Non-glare coating
- Screen adjustments
- Split screen
- Bold letters
- Blinking letters
- Reverse video
- Color capability
- Color resolution
- Standard keyboard layout
- Upper and lower case
- Sculptured keyboard
- Keyboard color
- Numeric keypad available
- Function keys available
- Automatic repeat feature
- Rollover function
- Detachable keyboard
- Movable screen
- Keyboard feedback
- Type of system bus
- Type of I/O bus
- Serial or parallel interface
- Number of expansion ports
- Type of operating system
- Application program availabilty
- Programming language availability
- Purchase price
- Printer speed
- Paper width
- Type of printer
- Dot matrix size
- Attachments available
- Color capability
- Graphics capability
- Bidirectional printing
- Logic seeking
- Clock frequency
- Voltage surge protection
- Training available
- Documentation available

XVI. MICROCOMPUTER MODEL DESCRIPTIONS

Altos ACS-8000. This microcomputer, which uses the Z80A microprocessor, is designed to support from one to four user terminals. The system has eight inch floppy and hard disks used to provide from 256K to 60 million characters of online storage. Memory capacity ranges from 64K to 208K characters. Extensive application software is available since the system supports the CP/M, MP/M and OASIS operating systems.

Atari 800. The MOS Technology 6502 microprocessor is used in this microcomputer. Memory capacity is limited to 48K characters and disk capacity is limited to 163K characters per 5 1/4 inch disk drive. Screen capacity is only 40 characters wide and the keyboard has upper case only and no numeric keypad. Software is limited since the disk operating system is a nonstandard version provided by the manufacturer.

Apple II Plus. The Apple II Plus, which uses the MOS Technology 6502 microprocessor, is a replacement for the Apple II which is no longer in production. This model is limited to 64K characters of random access memory (RAM) and 140K characters of storage on single side, single density 5 1/4 inch disk drives. The Apple disk operating system and the Apple version of BASIC are included in the 12K of read only memory (ROM). Screen capacity for an Apple monitor is only 40 characters wide with no lowercase and no numeric keypad on the keyboard. Expansion capability is limited with this five year old technology. A video display tube and disk drive are not standard offerings with the basic version of this model. Installation of expansion cards restricts air flow; the optional fan is recommended. Extensive software is available from Apple and many other vendors. However, the majority of software is game oriented.

Apple III. This model, which uses an MOS Technology 6502A microprocessor, comes with a 140K 5 1/4 inch disk drive but no video display tube. It has a 128K character memory capacity and includes the Apple disk operating system and Applesoft BASIC. The optional video monitor is a standard size with lower case; keyboard includes numeric keypad.

Commodore PET 4001. The Personal Electronic Translator model 4001 was one of the early models of microcomputers marketed in the U.S. It uses the MOS Technology 6502 microprocessor, and has 32K characters of RAM and 18K characters of ROM. The screen is 40 characters wide with no lower case. This model has a parallel port and the IEEE-488 input/output bus. A variety of application programs and languages are avaialbe from Commodore and other companies.

Commodore 8032. This model, which also uses the MOS Technology 6502 microprocessor, can be expanded to 96K characters of RAM. The 18K of ROM contains a BASIC language interpreter and an operating system with expanded functional cspabilities. A wide variety of peripheral equipment and software is available from Commodore and some independent companies.

Commodore Super PET 9000. This microcomputer is a model 8032 with a Motorola 6809 microprocessor. This provides the ability to have 98K characters of RAM and 36K characters of ROM. The Super PET supports all the software for the model 8032 plus many additional languages for the 6809 microprocessor.

Cromenco System Zero. This model, which uses the Z80A microprocessor, has a capacity of 128K characters of memory. The basic unit which uses an S100 bus does not include a disk drive or a video display tube. A proprietary disk operating system is available along with a variety of languages and application programs provided by Cromenco.

Cromenco System Two. The Z80A microprocessor is used in this model which does not include a video display tube but does include two 5 1/4 inch floppy disk drives. This system can support up to eight users with the CROMIX operating system. A wide variety of interface cards are available for connection to the S100 system bus.

Cromenco System Three. The System Three which also uses the Z80A microprocessor, has a memory capacity of 512K characters. This model includes dual 8 inch disk drives with 2.4 million characters of online storage. Disk capacity can be increased to 4.8 million characters. An RS-232C interface is provided along with the S-100 bus. A variety of peripheral equipment and software is available including the CROMIX multiuser operating system.

Dynabyte 5000. The Dynabyte 5000 series of microcomputers are Z-80A based S100 bus systems designed for upward compatibility throughout the entire product line. Memory capacity can be expanded to 400K characters and disk capacity is 1 million characters on two 5 1/4 inch dual density, dual side floppy disks. This system can be configured to support complex multi user, multiprocessor, networking operations. The CP/M operating system is available along with MP/M and OASIS.

DEC Rainbow 100. This microcomputer, manufactured by Digital Equipment Corporation, contains an 8 bit Z-80 microprocessor and a 16 bit Intel 8088 microprocessor. By using these two microprocessors, this model can process application programs designed for either the CP/M80 or the CP/M86 operating systems. Memory capacity is expandable to 256K characters and disk capacity is expandable to 1.6 million characters. Many ergonomic features are included in the screen and keyboard design. This model can emulate a DEC VT100 terminal to provide communications with larger DEC computer systems at speeds up to 9,600 bits per second.

DEC MATE II. This model uses a DEC 6120 microprocessor which is also used in a PDP-8 minicomputer. Memory capacity is 96K characters and disk space can be expanded to two dual floppy drives each with a capacity of 800K characters of data (the equivalent of 535 typewritten pages). This model was designed to be the basic building block in a total office system and has limited software available.

DEC Professional 325. This model, which uses a DEC F-11 microprocessor, is designed to be compatible with PDP 11 and VAX minicomputers. Software written under the P/OS multitasking operating system can be run on larger DEC minicomputers. Memory capacity is expandable to 256K characters and disk capacity is expandable to 1.6 million characters. Many ergonomic features are included in the screen and keyboard design. This model can also emulate a VT 100 terminal to provide communications with larger DEC computer systems at speeds up to 9,600 bits per second.

Eagle II. This model, which uses the Z-80A microprocessor, has a memory capacity of 64K characters. The standard configuration includes two single-sided, double density 5 1/4 inch floppy disk drives which can store 780K characters. A high resolution screen with a 9 x 11 dot matrix format is used on this microcomputer. The CP/M operating system and software for word processing and electronic spread sheet is included with this model. There is good communications capability and some expansion capability.

IBM Personal Computer. This microcomputer, which uses the Intel 8088 16 bit microprocessor, has a memory capacity of 1 million characters. Also included is 40K characters of read only memory (ROM) for storage of the operating system and BASIC language interpreter. A very high resolution video display tube with a 9 x 14 dot matrix format is used. Many ergonomic features are included in the design of the keyboard and display screen. Extensive capability is present for expansion with peripheral equipment from many independent vendors. A variety of protocols are available for communicating at speeds up to 19,200 bits per second. Standard features on this model include a built in fan and a power surge regulator as well as special maintenance diagnostics. The operating system used is the IBM Disk Operating System which is expected to become the industry standard for 16 bit microcomputers. Additionally, this system can support 16 programming languages and can use hundreds of application programs written by independent software companies.

Intertec Superbrain. Two Z-80A microprocessors are used in this microcomputer. One Z-80A performs all processor and screen related functions. The second Z-80A executes disk input/output operations.

Memory capacity is limited to 64K characters. Poor quality control in the production of this model often involves returning the microcomputer to the factory at Columbia, South Carolina. The warranty period begins upon shipment from the factory. This model may be used in a mulituser system called Compu Star . However, the Compu Star system has the reputation of not working as well as advertised.

Kay Comp II. This microcomputer, which uses the Z-80 microprocessor, is designed to compete with the Osborne portable microcomputer. The Kay Comp II has a 9 inch green phosphor screen which can display 80 columns and 24 rows of characters. This portable model includes a detachable keyboard with numeric keypad and two 5 1/4 inch floppy disk drives which each store 200K characters of data. Memory capacity is 64K characters. This inexpensive microcomputer includes the CP/M operating system and several application programs free of charge.

Micromation Mariner. This microcomputer is designed for use in a multiuser, multiprocessing environment. The central master processor that runs the operating system contains a Z-80A microprocessor and 64K characters of memory. This master processor and the multiuser software will support up to eight users. The user terminals also each contain a Z-80A microprocessor and 64K characters of memory to decrease processing and memory access time. All system components are connected via an S-100 bus, allowing fast communication between the master processor and user terminals. Disk capacity can be either a 2 million character floppy disk or a 21 million character Winchester style hard disk. A variety of communication protocols are available to allow communications with other networks or computers. Several types of multiuser software is available including MP/M which is upward compatible with CP/M.

Northstar Horizon. This microprocessor uses a Z-80A microprocessor and has 64K characters of memory and two 5 1/4 inch floppy disk drives included as standard. This model uses an S-100 system bus and includes three input/output ports. The system uses the Northstar DOS operating system, programming languages, and application programs. The CP/M operating system and compatible application programs and languages can be used with this microcomputer. This model can also be used in a multiuser configuration.

Osborne Model 1. This microcomputer, which uses the Z-80A microprocessor, is very inexpensive and portable. It has a detachable keyboard with numeric keypad and two 5 1/4 inch floppy disk drives which store 100K characters each. Memory capacity is 64K characters. Screen capacity is limited to 52 characters wide. This model includes the CP/M operating system and several application programs free of charge.

Radio Shack TRS-80 Model II. This microcomputer, which uses a Z-80A microprocessor has a 64K character memory capacity and includes an 8 inch floppy disk drive with a capacity of 416K characters. Since users cannot access the internal areas of this model, hardware expansion is very limited. This model uses the TRSDOS operating system with many languages and application programs available. However, many users change software to the CP/M operating system and its compatible languages and application programs.

Radio Shack TRS-80 Model III. This model uses a Z-80 microprocessor and contains 18K characters of read only memory (ROM) and 48K characters of random access memory (RAM). Two dual density 5 1/4 inch floppy disks are included with a total capacity of 368K characters. Screen size is limited to 64 characters wide by 16 rows for upper and lower case. The TRSDOS operating system is used for this model.

Radio Shack TRS-80 Model 16. This microcomputer uses an 8 bit Z-80A and a 16 bit MC 68000 microprocessor. Memory capacity is expandable to 512K characters. Minimum disk capacity is one double density, double sided 8 inch floppy disk containing 1.25 million characters. The 8 bit microprocessor in this model can process TRS-80 Model II programs. Three input/output ports are available for expansion with printers, plotters, digitizers, and modems.

Televideo TS802. This microcomputer, which uses a Z-80A microprocessor, has a 64K character memory capacity and a disk capacity of two 5 1/4 inch floppy disks with a total of 1 million characters of storage. This system can be expanded to a multiuser environment supporting 16 users. The CP/M operating system is available with many languages and application programs.

Vector Graphics Vector 3. This model uses the Z-80 microprocessor, has a 56K character memory capacity, and a 630K character disk capacity. The CP/M operating system is available with many languages and application programs.

Xerox 820. This microcomputer, which uses the Z-80 microprocessor, has a 64K character memory capacity and a 184K disk capacity. This model, which was designed primarily as a word processor, is a very slow computer. The CP/M operating system is available.

Zenith Data Systems Z89/Z90. These models, which use the Z-80 microprocessor, have a memory capacity of 64K characters and a disk capacity of 160K characters. Zenith software is available as well as the CP/M operating system and associated software.

Victor 9000. This microcomputer, which uses the 16 bit Intel 8088 microprocessor, is designed to be a plug compatible competitor to the IBM Personal Computer. This model has an internal memory capacity of 896K characters and a disk capacity of 1.2 million characters. All the physical and ergonomic characteristics of the IBM Personal Computer are also standard on this model. Both the CP/M-86 and MS-DOS operating systems are available for this microcomputer.

TABLE 5

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Altos	Atari	Apple
MODEL	ACS 8000	800	II Plus
MICROPROCESSOR	Zilog Z-80A	Mos Technology 6502	Mos Technology 6502
MEMORY CAPACITY	512K	48K	64K
DISK CAPACITY	29 Meg Hard Disk	163K, 5¼" single side, single den	140K, 5¼" single side, single den
SCREEN CAPACITY	80 characters wide by 24 rows	40 characters wide by 24 rows	40 characters wide by 24 rows
SCREEN COLOR	White on black	White on black	White on black
KEYBOARD FEATURES	Standard keyboard, numeric pad, U/L case	Standard keyboard, no U/L case, no keypad	Upper case only, no keypad
ERGONOMIC FEATURES	None evident	None evident	None evident
PERIPHERAL CAPACITY	4 users and many I/O devices	Several I/O ports	6 ports
SOFTWARE	Extensive	Good from Atari	Extensive from Apple and Others
PURCHASE PRICE	$8,000-$12,000	$1,000-$3,000	$2,615-$3,610

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Apple	Commodore	Commodore
MODEL	III	PET 4001	CBM 8032 B
MICROPROCESSOR	Mos Technology 6502	Mos Technology 6502	Mos Technology 6502
MEMORY CAPACITY	128K	32K	96K
DISK CAPACITY	140K, 5¼" single side, single den	340K, 5¼" dual drive	1,000K, 5¼" dual drive
SCREEN CAPACITY	80 characters wide by 24 rows	40 characters wide by 25 rows	80 characters wide by 25 rows
SCREEN COLOR	Green phosphor	Green phosphor	Green phosphor
KEYBOARD FEATURES	Standard keyboard, U/L case , numeric keypad	Standard keyboard, upper case only, numeric pad	Standard keyboard, U/L case, numeric pad
ERGONOMIC FEATURES	Sculptured keyboard	None evident	None evident
PERIPHERAL CAPACITY	8 ports	15 I/O ports	15 I/O ports
SOFTWARE	Extensive from Apple and Others	Good from other companies	Good from other companies
PURCHASE PRICE	$3,495-$4,070	$995-$3,100	$1,495-$4,300

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Commodore	Cromenco	Cromenco
MODEL	S P 9000	System Zero	System Two
MICROPROCESSOR	Mos Technology 6502 and Motorala 6809	Zilog Z-80A	Zilog Z-80A
MEMORY CAPACITY	134K	128K	512K
DISK CAPACITY	1,000K, 5¼" dual drive	780K, 5¼" dual den, dual drives	780K, 5¼" dual den, dual drives
SCREEN CAPACITY	80 characters wide by 25 rows	80 characters wide by 24 rows	80 characters wide by 24 rows
SCREEN COLOR	Green phosphor	White on black	White on black
KEYBOARD FEATURES	Standard keyboard, U/L case, numeric pad	Standard keyboard, U/L case, numeric pad	Standard keyboard, U/L case, function keys, numeric pad
ERGONOMIC FEATURES	None evident	Detachable keyboard	Detachable keyboard
PERIPHERAL CAPACITY	15 ports	S100 Bus and parallel port	S100 Bus and 6 ports
SOFTWARE	Very good, many languages	Extensive	Extensive
PURCHASE PRICE	$1,995-$6,000	$2,995-$6,000	$4,695-$15,000

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Cromenco	Dynabyte	DEC
MODEL	System Three	5000	Rainbow 100
MICROPROCESSOR	Zilog Z-80A	Zilog Z-80A	Z-80 and Intel 8088 Dual Processor
MEMORY CAPACITY	512K	400K	256K
DISK CAPACITY	4,800K, 8" dual den, 4 drives	1,000K, 5¼" dual side, dual den	800K, 5¼" dual den, dual drives
SCREEN CAPACITY	80 characters wide by 24 rows	80 characters wide by 24 rows	80 characters wide by 24 rows
SCREEN COLOR	White on black	White on black	White on black
KEYBOARD FEATURES	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, U/L case, numeric pad	Standard keyboard, U/L case, function keys, numeric pad
ERGONOMIC FEATURES	Detachable keyboard	None evident	Sculptured, detachable keyboard, tilt screen
PERIPHERAL CAPACITY	S100 bus and 6 ports	S-100 bus	3 ports
SOFTWARE	Extensive	Standard CP/M MP/M, OASIS	Extensive
PURCHASE PRICE	$8,000-$18,000	$7,000-$11,000	$2,675-$4,900

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	DEC	DEC	Eagle
MODEL	DEC Mate II	Professional 325	II
MICROPROCESSOR	DEC 6120	DEC F-11	Zilog Z-80A
MEMORY CAPACITY	96K	256K	64K
DISK CAPACITY	800K, 5¼" dual den, dual drives	800K, 5¼" dual den, dual drives	780K, 5¼" dual den, dual drives
SCREEN CAPACITY	80 characters wide by 24 rows	80 characters wide by 24 rows	80 characters wide by 24 rows
SCREEN COLOR	White on black	White on black	Green phosphor
KEYBOARD FEATURES	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, U/L case, function keys, numeric pad
ERGONOMIC FEATURES	Sculptured, detachable keyboard, tilt screen	Sculptured, detachable keyboard, tilt screen	None evident
PERIPHERAL CAPACITY	3 ports	4 ports	3 ports
SOFTWARE	Limited from DEC	Limited from DEC	CP/M and many packages
PURCHASE PRICE	\$3,000-\$5,100	\$3,375-\$8,000	\$2,695-\$4,995

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	IBM	Intertec	Kay Computers
MODEL	Personal Computer	Superbrain	Kay Comp II
MICROPROCESSOR	Intel 8088	(2) Zilog Z-80A's	Zilog Z-80
MEMORY CAPACITY	1,000K	64K	64K
DISK CAPACITY	320K, dual den, dual side	350K, 5¼" dual den, dual drives	400K, 5¼" dual den, dual drives
SCREEN CAPACITY	80 characters wide by 25 rows	80 characters wide 25 rows	80 characters wide 24 rows
SCREEN COLOR	Green phosphor	White on black	Green phosphor
KEYBOARD FEATURES	Standard keyboard, U/L case, numeric pad	Standard keyboard, U/L case, numeric pad	Standard keyboard, U/L case, numeric pad
ERGONOMIC FEATURES	Sculptured, detachable keyboard, tilt screen	None evident	Detachable keyboard, portable
PERIPHERAL CAPACITY	Many I/O devices	S-100 bus and 2 ports	3 ports
SOFTWARE	Extensive	CP/M and many applications	CP/M and many applications
PURCHASE PRICE	$2,490-$2,980	$2,349-$3,055	$1,795-$2,795

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Micromation	Osborne	Radio Shack
MODEL	Mariner	Model I	Model II
MICROPROCESSOR	Zilog Z-80A	Zilog Z-80A	Zilog Z-80A
MEMORY CAPACITY	64K per user	64K	64K
DISK CAPACITY	2,000K, 8" dual side, dual den	200K, 5¼" dual drives	416K, 8" dual density
SCREEN CAPACITY	80 characters wide by 25 rows	52 characters wide by 24 rows	80 characters wide by 24 rows
SCREEN COLOR	White on black	White on black	White on black
KEYBOARD FEATURES	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, numeric pad	Standard keyboard, U/L case, numeric pad
ERGONOMIC FEATURES	Detachable keyboard	Detachable keyboard	None evident
PERIPHERAL CAPACITY	Supports 8 users	3 ports	2 ports
SOFTWARE	Extensive	CP/M and many applications	Extensive
PURCHASE PRICE	$4,500-$11,400	$1,795-$2,795	$3,500-$6,000

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Northstar	Radio Shack	Radio Shack
MODEL	Horizon	Model III	Model 16
MICROPROCESSOR	Zilog Z-80A	Zilog Z-80	Zilog Z-80A and Motorala 68000
MEMORY CAPACITY	64K	48K	512K
DISK CAPACITY	360K, 5¼" dual drives	368K, 5¼" dual den, dual drives	2,400K, 8" dual den, dual drives
SCREEN CAPACITY	80 characters wide by 24 rows	64 characters wide by 16 rows	80 characters wide by 24 rows
SCREEN COLOR	White on black	White on black	Green phosphor
KEYBOARD FEATURES	Standard keyboard, U/L case, numeric pad	Standard keyboard, numeric keypad	Standard keyboard, U/L case, numeric numeric keypad
ERGONOMIC FEATURES	None evident	None evident	Detachable keyboard
PERIPHERAL CAPACITY	S 100 bus and 3 ports	2 ports	3 ports
SOFTWARE	CP/M and Northstar software	Extensive	Extensive
PURCHASE PRICE	$4,195-$7,610	$1,995-$2,495	$4,999-$5,798

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Televideo	Vector Graphics	Xerox
MODEL	TS802	Vector 3	820
MICROPROCESSOR	Zilog Z-80A	Zilog Z-80	Zilog Z-80
MEMORY CAPACITY	64K	56K	64K
DISK CAPACITY	1,000K, 5¼" dual den, dual drives	630K, 5¼" dual side	184K, 5¼" dual drives
SCREEN CAPACITY	80 characters wide by 25 rows	80 characters wide by 24 rows	80 characters wide by 24 rows
SCREEN COLOR	Green phosphor	White on black	White on black
KEYBOARD FEATURES	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, with numeric pad, U/L case	Standard keyboard, U/L case
ERGONOMIC FEATURES	Detachable keyboard	None evident	None evident
PERIPHERAL CAPACITY	3 ports	4 ports	3 ports
SOFTWARE	CP/M and many applications	CP/M and many applications	CP/M available
PURCHASE PRICE	$2,900-$3,600	$3,695-$7,500	$2,995-$6,500

MICROCOMPUTER CHARACTERISTICS

MANUFACTURER	Zenith	Victor	
MODEL	Data Systems Z-89F	9000	
MICROPROCESSOR	(2) Zilog Z-80	Intel 8088	
MEMORY CAPACITY	64K	896K	
DISK CAPACITY	160K, 5¼" dual den	1,200K single side, dual drives	
SCREEN CAPACITY	80 characters wide by 24 rows	132 characters wide by 24 rows	
SCREEN COLOR	White on black	Green phosphor	
KEYBOARD FEATURES	Standard keyboard, U/L case, function keys, numeric pad	Standard keyboard, U/L case, function keys, numeric pad	
ERGONOMIC FEATURES	None evident	Detachable keyboard, tilt screen	
PERIPHERAL CAPACITY	3 ports	many peripherals	
SOFTWARE	Zenith software and CP/M	CP/M-86 and MS-DOS included	
PURCHASE PRICE	$2,900-$3,500	$5,000-$6,000	

REFERENCE READINGS

I. Introduction

The age of inexpensive computers and software is also the age of do-it-yourself computing. A vendor who sells a computer for $3,500 or a software package for $250 can provide little technical assistance. The salesperson in a retail computer center can ill afford to spend days educating a single purchaser. It is clear that transit and paratransit operators, state, regional, county and city planning agencies and traffic engineering departments in the many thousands are poised to purchase microcomputers over the next 5 years. UMTA and FHWA cannot begin to provide training in basic microcomputer literacy to these thousands of persons. Federal training and assistance will need to focus primarily on specialized transportation issues, software and usage.

Fortunately, there are numerous and growing resources for those who must attain a basic understanding of microcomputer systems. Public and university libraries are becoming well stocked with publications and periodicals on the subject. Universities, communtiy colleges, county and other agencies are offering continuing education courses in microcomputers.

The below references are intended to direct you toward some comprehensive sources available nationally. Your local resources are no doubt considerable but you must find these yourself.

II. References

A. A very comprehensive, single source of all kinds of computer information is the "Datapro" series. The reports are voluminous and regularly updated at a high subscription fee. Each series includes a (usually) excellent basic introduction to the subject then a review of commercial products available. They generally also include listings of vendors and user ratings of products. See your public or university library or ADP department for a copy you can refer to. Make sure somebody is keeping it up to date.

1. Datapro Directory of Small Computers (Vol. 1 & 2)

2. Datapro Directory of Microcomputer Software (Vol. 1 & 2)

3. Communications Solutions (Vol. 1 & 2)

4. Other useful volumes on graphics software, etc.

All published by:

Datapro Research Corporation
1805 Underwood Blvd.
Delran, New Jersey 08075
(609) 764-0100

B. With the deluge of written material one is expected to consume, other media such as audio or video are a welcome relief. McGraw Hill has produced a fine audio cassette/workbook package for individual self-training in basic microcomputer literacy. It consists of two workbooks and about 10 audio casette tapes. The instruction covers terminology, equipment, software, communications and programming in the "BASIC" language. At $95.20, the package is well worth the investment for an agency with a number of persons who need such training. Also included in the package is a report excerpted from the Datapro series (discussed above) which compares features of many popular microcomputers. A 15 day trial, money-back period is advertised. For ordering information:

"Microcomputer At-Home Seminar"
McGraw Hill Continuing Education Center
3939 Wisconsin Avenue, N.W.
Washington, D.C. 20016
(800) 323-1717 (toll free) or
(202) 244-1600

C. As rapidly as new equipment and software products are introduced, no source can be as current as the periodicals concerned with microcomputers. Several of the more widely read are listed below. Generally, these are also available in public libraries so you need not subscribe.

BYTE (monthly magazine, $19 per year)
Subscription Department
P.O. Box 590
Martinsville, New Jersey 08836
(800) 258-5485

INFO WORLD (weekly newspaper, $25 per year)
Circulation Department
375 Cochituate Road
P.O. Box 880
Framingham, Massachusetts 01701-9987
(800) 343-6474

Personal Computing (monthly magazine, $11.97 per year)
P.O. Box 294
Boulder, CO 80321

Popular Computing (monthly magazine, $15 per year)
P.O. Box 307
Martinsville, New Jersey 08836

If you are looking for articles on specific subjects, an index to some 23 microcomputer periodicals is available, perhaps at your public or University library. Each article is described in an abstract. The index is:

Microcomputer Index (Published quarterly, $30 per year)
2464 El Camino Road
Suite 247
Santa Clara, CA 95051

D. Moving software from one microcomputer to another is often difficult due to differing operating systems. The operating system problem can largely be overcome by using one that is available on a great variety of computers. In the microcomputer field, the operating system that is currently available on the greatest variety of popular machines is the UCSD p-System Version IV. It is available (at extra cost) for the Apple II, Apple III, TRS Model II, (Model III and Model 16 versions are under development), IBM PC, Osborne 1, Xerox 820, TI 200, TI99/4A, HP-87, Victor 9000 and others. Languages one may use with the system are BASIC, PASCAL and FORTRAN 77.

UMTA (URT-41) and FHWA (HHP-22) have adopted this operating system and the PASCAL language as the standard for software developed by these offices. As a minimum, all software developed by these offices will work on this system. Some programs may be made available for other operating systems as well, such as the popular CP/M system. Persons getting started in microcomputers should know about the UCSD p-System and consider its availability for equipment being selected.

The best single source of information about this operating system is:

Softech Microsystems
9494 Black Mountain Road
San Diego, CA 92126
(714) 451-1230

Softech will send you a brochure describing the p-System and a catalog of commercial software available to run under the p-System (if you ask for it).

The PASCAL language itself is well described in the book:

"Beginners Guide for the UCSD Pascal System"
by Kenneth L Bowles
McGraw Hill 1980

Which can be purchased for about $12 or may be available at a university or public library.

Another good PASCAL language book is:

"Programming in PASCAL: Revised Edition"
by Peter Grogono
Addison-Wesley Publishing Company, Inc.

E. Miscellaneous References:

1. "The Small Business Computer I.Q. Quiz" (10 page booklet) guidance on selecting and integrating a microcomputer into an office environment. Single copies available free from:

   Alpha Microsystems
   17881 Sky Park North
   P.O. Box 18347
   Irvine, CA 92713
   (714) 957-1404

2. Toong, Hoomin D., and Amar Gupta, "Personal Computers." Scientific American, December 1982, pp 87 - 105. "An account of their hardware, software applications and current proliferations." The article is an excellent primer of the anatomy of a microcomputer written for the untrained person.

3. The monograph "Microcomputer Applications in Human Service Agencies" (included in this publication) has been revised by the FHWA to make it more applicable to traffic engineering agencies. Those interested in receiving a copy of the revised monograph, "Microcomputer Applications in Traffic Engineering Agencies" should write:

   Mr. King Gee
   Federal Highway Administration
   Room 306
   1000 North Glebe Road
   Arlington, VA 22201-4799
   (703) 757-9080

4. Glossary of Microcmputer Terminology:

   "Computer Glossary." Video and Home Computer Buyers Guide, Vol. 1, No. 1, 1982, pp 92-95

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