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SELECTION AND SIZING OF MINICOMPUTERS FOR ADMINISTRATIVE
APPLICATIONS IN THE SMALL BUSINESS ENVIRONMENT

by

DAVID CHARLES MINSON

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A MASTER'S REPORT

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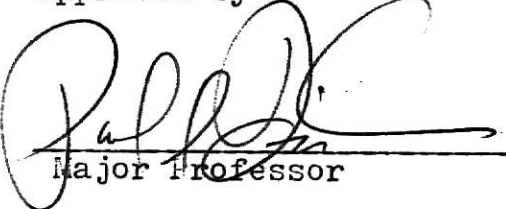
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CHAPTER I

1.1 Introduction--The tide associated with minicomputers continues to swell. Capabilities have expanded and prices dropped, a rare occurrence for most consumers, and possibly for this reason (as well as numerous others) managers and owners of small businesses are feeling the urge to automate their businesses. The introduction of megaminis, those machines capable of directly addressing over a million memory locations, has most recently added to the flood. As COBOL compilers for these computers become available, their appeal and practicality to the business world is greatly expanded. The small businessman is beginning to feel that automation is certainly within his financial grasp. What's to keep him from making the plunge? Nothing, in many cases. And, to that, a footnote might be added, "Unfortunately."

It has been the experience of numerous of these businessmen to fall victim to the Madison Avenue sales approach of computer vendors whose products are as aesthetically packaged as their marketing men can make them; whose salesmen quote "mega-capabilities" for their own product against "nano-capabilities" of their competition. Here the consumer in inundated with comparative data, all of which are oriented to show that machine X is the one which best satisfies his needs. He is shown "in black and white" where a given computer will reduce his personnel requirement by large

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percentages, provide immediate access to business performance data and forecasting information that will virtually eliminate the guesswork from decision making. Of course, whether or not any or all of these claims are true or even partially so depends on the type of business with which one is concerned as well as the computer. It still falls on the man at the top to make a prudent decision as to the type of computer, as well as the size system in which to invest. Just how can he go about making such a decision?

It wasn't too many years ago that the manmouth businesses in this country were making these decisions for the first time. The principle difference being the large companies had vast amounts of resources with which to investigate the problem and help them to make the best decision. Books written on the subject outline very elaborate and detailed analyses, studies and implementation actions which were most appropriate, and certainly warranted when one considered that the cost of the system would be measured in multiple millions of dollars. Even given such prudent advice as published in business periodicals and computer selection books, large companies fell victim to impulsive buying. Wrong decisions were made for what would appear to be all of the right reasons and occasionally, right decisions would be made for the wrong reasons. Whatever caused it, there is little chance that the smaller businessman, with far fewer resources at his disposal is going to make a better decision.

Though the investment which the small businessman chooses to make in a computer is proportionally equal to that of the larger companies, the requirement for extensive studies would push the cost of the computer out of his range.

An additional factor which confronts the prospective minicomputer buyer is the choice available. He has a far greater number of vendors from which to choose than was ever the case for large businesses. In an effort to more graphically display the plight of those involved in computer selection, a series of case studies follows. Two of these are of small businessmen interested in minicomputers. Two others are reports by persons directly involved in the acquisition of large computer systems. The cases are offered as examples of how these type decisions are being made or have been made in the past.

The remainder of this report will address the possible solutions to the problems of automation within the business environment. It will investigate the characteristics, capabilities and limitations of minicomputer systems. Various alternatives to an inhouse system will be discussed. Finally, a proposal is made of a simplified method by which the businessman may estimate the size of the system required in his company.

1.2 Case A:

Mr. A, the owner of a small but successful rental agency, felt the need to automate as his business began to expand to the point that clerical and administrative personnel costs were becoming excessive. The bookkeeping in his company required a great amount of attention to detail as it involved a variable pricing scale on his equipment depending on the type customer. Mr. A became aware that the vast majority of his time was being consumed in attending to complaints which were directly attributable to his office staff. There were numerous instances of customer dissatisfaction, as well as problems with his other employees. It was at this point that he made the decision to automate.

Mr. A's desires were quite modest. He merely wanted to be able to output a correct invoice, based on the variable price schedule on his rental items and provide that to his route salesmen at the beginning of their day's run. Mr. A's first thoughts were to solicit assistance from a service bureau. He contacted two different bureaus. The first was located at a distance that would have required the use of the mails and involved a week or more turn-around time. This he felt would be unsatisfactory, not giving him the control over matters to the extent that he desired. The second bureau offered to install an input device on his premises but would only be able to handle regular rental customers,

and would not be able to process those customers who came
in on an irregular basis. He then contacted a local business
that had already installed equipment, but was not a regular
service bureau. Negotiations broke down with this company
over the price of software development.

By this time, the situation within the company was getting
quite critical. Mr. A decided that he would have to go to
inhouse equipment. At this point he contacted a local sales
representative of a major computer company and asked if he
had a computer that would make out an accurate invoice, to
which the salesman responded affirmatively. He quoted Mr. A
a price in the neighborhood of $16,000, and negotiations were
begun. As they progressed, it evolved that required peri-
pherals would cost an additional $8,000 and software another
$3,000. Mr. A then sought a quote from another company and
learned that their prices were approximately twice that of
the company with which he was negociating. Consequently, an
order was placed for the system with the $16,000 CPU. Terms
for the contract called for development of associated soft-
ware to be completed and delivered with the hardware in
six months from the date of the contract. The machine for
which Mr. A had contracted was a relatively untried model and
production difficulties pushed the delivery date back an
additional 3 months. Meanwhile, the software engineers
were having difficulties programming the new machine and had

not completed the software package even by the time the hardware was delivered some three months after the original delivery date.

When the hardware arrived, Mr. A refused to sign the delivery receipt since no software accompanied it. Contact with the computer company officials resulted in two full time programmers being sent to complete the programs for the system. An additional four months passed while the programmers worked to develop the software for the computer. Company officials became concerned over matters and the fact that they were yet to receive any payment or rent on this item of hardware. Finally, Mr. A agreed to begin paying rent the following month after being assured that the system would be running at that time. When runs were attempted that following month, the results were disasterous. Little or no improvement was noted the next month. The third try, still another month later, began to give encouraging results. By the end of the third month, the system was beginning to out perform the manual system and by the end of the fourth month of testing, the decision was made to convert to the computerized system and eliminate the manual backup.

The system was finally operational some 12 months after the original contracted delivery date. Meanwhile, Mr. A realized that the system was far too complicated and the language too difficult for his present office staff to operate.

He was able to hire a graduate student from a local university to assist him in running his newly developed computer center. Mr. A has since been able to reduce his office staff from four full time employees to two full-time and one two-day-per-week employee. However, the increased wages of the one new employee plus the rental costs of the computer more than offset the difference in cost of the two levels of employ-ment. He is presently attempting to offer his facility to other businessmen in the community in the form of a small service bureau. The computer is operating at about 50% capacity for a single shift operation. He feels the service bureau arrangement appears to offer the best chance to make this a profitable venture.

On the positive side of the ledger, the system is pro-viding Mr. A with just the type of information and service he had desired. Customer dissatisfaction with billing and other clerical services has been virtually eliminated. He has experienced a notable decrease in late or unpaid accounts. Mr. A is generally satisfied with the installation, however, when questioned, he looks upon his computer more as a necessary evil than a panacea.

He offers the following as advice to those who are considering the acquisition of a computer:

1. Engage a reputable consultant to examine the organ-ization and determine the size of computing system that will

satisfy the needs of the company.

2.   Contact numerous computer companies for estimates on systems of the given size, and receive estimates for software and hardware.

3.   It is imperative that top level management be in on the production of the software from the very earliest stages of its development.

1.3 Case B:

Mr. B is the director of a large computing center. He had previously had on his premises an IBM 360/50 which was running literally 24 hours each day. In an attempt to isolate those areas of the system which were causing the backlog, hardware monitoring was conducted. Results of the monitoring revealed that the entire system was running to capacity and that no single facet of the system was responsible for the overload. It was at this point that a need was realized for additional computing power. Mr. B prepared a report on the desireability of upgrading the present system, which included the financial arguments for the upgrading, and circulated this among various other department heads to gain their support before making a formal proposal to top management. Top management was persuaded that the requirement was in fact valid. Plans were made to have a third party purchase the computer within certain dollar amounts, and then, in turn, rent the computer from this third party. In the original plan, financial implications looked so good that top management decided to by-pass the third party plan and make an outright purchase of the required computer.

Having tentatively settled the financial aspects of the purchase, a set of preliminary functional specifications were prepared. Mr. B solicited assistance from the principle departments which used the computing facility to prepare a

prediction of the future needs of each of the departments.
Response was generally poor, forcing Mr. B to make the pre-
diction based almost solely on his own experience in the
computing center. His estimate was presented as a gradually
rising demand curve, predicting a need for approximately
four times the computing and output power that his present
system had at the end of a seven year period.

Six vendors were notified of the preliminary specifi-
cations. They were invited to attend open meetings to
discuss the validity of the specifications and to comment
on the possibility of being able to satisfy the specifi-
cations for a given dollar expenditure. In addition,
Mr. B provided a set of tentative benchmarks which could be
used by each of the vendors to determine if the proposal
was feasible. Of the six vendors notified, four attended
the open discussions. All attending vendors took copies
of the proposed benchmarks.

Having interviewed all of the interested companies, the
preliminary specifications were further refined and prepared
in format of a Request for Proposal and sent out to all of
the six original companies. Response was received from two
companies. It was further announced that the criteria for
final selection would be the system costing least which com-
plied with the desired specifications. During the time of the
benchmarking, the computing center interacted fully with the
vendors, but was careful not reveal competetive vendor

progress. From reports received from both companies, it was necessary to reiterate that the only requirement was to meet the demand curve provided in the functional specifications.

In the final analysis, both companies met the specifications, however, one company's bid was some eight percent lower than the other. Based on this consideration alone, the lower bid was selected. A series of tests were made with the new equipment to insure that the winning company's proposal was in fact valid prior to making the final conversion.

The conversion was made with a minimum of difficulty. It wasn't until after the conversion was completed that it was discovered that the configuration of the system as it existed precluded exercising the capability of being able to run multiple operating systems simultaneously due to a shortage of disk space.

This lack of disk space, coupled with a generally poor response by the vendor to servicing a large number of bugs in the primary operating system, are the chief complaints of Mr. B. Overall, he is generally satisfied with the acquisition.

1.4 Case C:

Mr. C is the owner of a relatively small wholesale business. The business is divided into three separate operations. Due to the nature of the various operations it is necessary to treat them almost as separate business entities. Company bookkeeping is presently performed on a bookkeeping machine which is running from 10 to 12 hours each day. Even at that level of operation, it is only able to provide the minimum essential bookkeeping services to keep the company operating. Inventory control, general ledgers, books, depreciation, accounts payable and other functions are done manually. Mr. C feels a real need to automate and is currently investigating the minicomputer market in an attempt to locate equipment that will be able to give thim the kind of accounting and reports that he feels essential to his business. Due to the size of his organization, however, he feels a severe financial constraint and is only willing to spend an additional $200 per month over what he is now paying in rental for his bookkeeping machine.

Mr. C has done a considerable amount of research in the area to help him make a prudent decision, to include investigating the following options:

1. Buy hardware outright and have the computer company arrange for programming.

2. Buy equipment and arrange for own programming.

3. Solicit a programmer first and purchase equipment based on his recommendation--compatable with the programs.

4. Leasing options with above.

5. Service bureau arrangements.

6. Engaging consulting services.

He has investigated seven or eight vendors that he feels would be able to provide him with service on a timely basis. He is somewhat discouraged at the rising cost of software, and has figures from three or four years ago quoting him software costs which are one third that of similar quotes today. Additionally, he is somewhat overcome by the costs of hardware that will do those things that he feels essential to his business.

In addition to desiring programs to perform inventory control, general ledgers, tickets and accounts receivable, accounts payable, depreciation and payroll, he desires to have immediate access to the information which is stored on file. He sees that no matter what system he goes to he will have to provide personnel for daily input. Mr. C views software maintenance as a relatively minor problem and feels that office personnel could readily write some of the more minor programs. As a matter-of-fact, there is only one area of his operation which he feels would require outside programming assistance.

Mr. C recognizes that there is considerable pressure

for him to remain with the vendor which is providing him with his bookkeeping equipment, for the simple reason that he will end up paying double rental fees when the time comes to make the final conversion and he is having to keep his old equipment on hand while testing the new system.

In considering which system to buy, Mr. C is concerned primarily with cost, I/0 capability and maintenance. CPU execution characteristics are of no concern to him in his applications outside of I/0 capability. Mr. C believes his situation to be typical of the vast majority of small businessmen.

1.5 Case D:

Mr. D is the Systems and Procedures manager for a large insurance company and has had the final voice in recommending to top management the computing system that will be employed in that company for some 20 years. During that time the company has used the products of a single computer company and has had little inclination to change. The principle reason for this dedication is the hardware service that is available and received from this computer company. Cost is a relatively minor consideration, as Mr. D estimates that he doubts that top management would consider it worthwhile to change to another line of machines unless there could be a dollar savings of greater than 40%. As a consequence, the insurance company has its entire line of office equipment provided by the computer company.

Mr. D is comfortable discussing computers. His education in this area is self generated for the most part. He was involved in the programming of the company's first computer and has followed subsequent development in the computer industry. He has a great deal of respect for and confidence in the computer company's salesmen and technical analysts. He is most appreciative of their efforts to keep him and the insurance company abreast of the latest developments in the industry.

The insurance company's most recent upgrading of their

computing facility was done in an effort to place the company's entire record system on disk. Until the most recent upgrading, a large portion of these records were on tape, making access too slow for a business of this size. The new system offered greater disk storage space per disk at a cheaper price per disk than the old system. Also, the new system offered a second channel for input operations, thereby promising to speed up this phase of the company's operation.

Mr. D feels that the entire computer operation of the insurance company is heavily input bound. For this reason he has pushed for, and has had the input operation almost entirely converted from card input to CRT input terminals. The company is presently using some 24 CRT's, used principally for input operations, 3 slow speed printers and one high speed printer. None of the printers are employed close to maximum capacity, whereas, Mr. D estimates that the CRT's are kept busy approximately 70% of the time. He would like to use the CRT's closer to 90% of the time. He has most recently become aware that due to the limited channel access to the CPU that data entry is not going as fast as it might be. Also, with the addition of new programs and automation of other facets of the insurance company's related business activities, Mr. D anticipates that there is a possibility of a requirement to further upgrade to the next higher computer model. This will provide an additional channel for input, a requirement as this model reaches the optimum number of input

devices.

The object of the insurance company is to have its entire record system placed on disk. As previously stated, the company is presently involved in making this conversion-- from tape to disk. Most recently, the company investigated the possibility of introducing a data base management system to more efficiently store exising records. This idea was abandoned due to the cost of such a system.

The insurance company employs a programming staff of 12 personnel. This staff, just recently increased in size, performs all of the software development for the insurance company. Modifications on the operating system actually performed by the programming staff are minimal.

Mr. D is extremely satisfied with the system that the company has. The one forray away from the computer company in an effort to save money was in the purchase (or leasing) of the CRT's. After several unfortunate experiences in obtaining service on these CRT's, they were replaced by the computer company's models. With that one exception there has been no effort to investigate the capabilities of com- petetive systems. Mr. D is convinced that there is no company that would be able to provide the hardware service that is so essential to the operation of the insurance business.

1.6 Lessons Learned:

A good number of points can be made from these case studies. The methods by which computers are selected for any particular application varies to a point that it virtually defies identification. It is a factor of the type business, resources available to that business, the geographic location of the business, as well as the experiences and personalities of those persons involved in the selection.

One common factor in all of these selection processes is the almost total dependence of the consumer on the integrity of the vendor. Even the most wary computer expert is subject to the same pitfalls that befall the relatively inexperienced. Though the expert is better able to identify and enumerate those characteristics he desires, they are more likely to be so complicated that he is apt to be unable to verify their existance, in the final analysis, until it is too late.

On the other hand, the small businessman appears to be very reluctant to seek outside assistance, and consequently labors under a vast array of misconceptions. He suffers the trauma of what might be termed the psychology of the entrepreneur. He is, by and large, an independent, hard working individual who expects the same kind of service for his dollar as he gave in earning it. He is comfortable with those things which surround him and with which he is familiar, and similarly uncomfortable with those things that he does not fully understand. His knowledge of computers, in particular,

seems to be from his own independent research. His experience in this area may well be limited to contact with friends and acquaintances who have actually taken the big step. For the most part, these experiences have been other than pleasant. From this, and contact with a few computer salesmen, he developes his own ideas about the vendors and vendor services.

When a businessman begins his education in the field of computers, he is receptive to the computer's capabilities and readily recognizes the vast number of applications that there are in his business for such a device. He can easily become enthusiastic about these capabilities and as easily be misled when he reads the prices associated with the bare CPU. He quite naturally wants to explore the full range of the computer from random access and instantaneous availability of information, to CRT's, multi-programming, line printers, etc. He is not quite so receptive to the added costs of such features.

Computer buying is fraught with hidden costs. A principle contributor to the hidden costs is the costs associated with the development of software for the specific applications within the business. One comment that did arise in almost every interview taken in developing the case studies was that each of those persons interviewed stated that his particular situation was unique. As a consequence, he was not in a position to use much, if any, of the prepackaged software that was offered by the vendor. These businessmen were

very reluctant to entertain ideas of changing their business operation to make it possible to use some of these software packages, fearing that such changes would seriously affect their businesses. At the same time, these same businessmen are just as reluctant to pay the cost of development for custom tailored software. The high cost of software is as unpalitable to him as to the rest of the computer consumers.

Also, in this area of software, the consumer is likely to find that it requires considerably more skill to develop the type of software that is desired than he was actually led to believe when he was making his initial investigation into the possibility of using a computer.

A number of the smaller minis may employ languages of assembly level. Considerable time must be spent in training personnel to operate the equipment and become familiar with programming. The businessman invariably does not have the time to devote to programming. He therefore becomes heavily dependent on his operators--a fact he may not realize until after he has actually made the transition to automation. It is in this area that the promise to cut labor costs usually fails to materialize. If one is able to reduce his staff, it is often at the expense of replacing some outgoing personnel by those with higher skill levels, and consequently, higher wages.

The high cost of peripheral devices is another concern of the businessman. The cost of such devices pretty well dictates the size of the system the businessman will select.

The businessman will either end up lowering his initial expectations or spending more than originally contemplated.

Still another conflict of interest which plays an important part in the mind of the businessman, and ultimately in the configuration of his system, is his reluctance to depart from some type of hard, physical file system. These types of files are basically inconsistent with the entire concept of automation. Practically speaking, they work well in the very smallest of applications, but greatly slow the entire operation in all cases. To get the businessman to relinquish this type of file system is a difficult task.

Alternatives to the inhouse system did not appear to be given their just consideration in these cases. It seems that the businessman has a feeling of lack of control over his company's operation when he enters into service bureau or time sharing arrangements. There is a definite air that leaves one the impression that the businessman feels that if he cannot physically see the computer he does not have the desired access to it. The fact that there are few such operations in smaller cities, and that service would have to be sought from hundreds of miles away, perpetuates this impression.

Yet another consideration which seems to be too quickly swept aside by the independent spirit of the small businessman is the use of consulting services. Small businessmen, in particular, have a real aversion for the use of such services.

They generally seem to feel that consulting services are more
bothersome than they are worth. They use up a great deal of
the businessman's time, as well as that of his employees
in attempting to gain an understanding of the business
operation. For the most part, the recommendations that
are made are not revolutionary enough to make the business-
man feel that he couldn't have arrived at a similar conclu-
sion. In the field of computers, consultants are often
tied to specific lines of hardware. Those who are not
will generally offer some sort of software development
scheme in conjunction with their consulting services. This
undoubtedly creates a certain element of mistrust in the
mind of the businessman as he senses the possibility of a
conflict of interest. Additionally, the cost of consulting
services are quite high. If the hardware, software, or
both are acquired in conjunction with the consulting service,
the cost is pushed even higher. It is extremely difficult
for the businessman to rationalize that in the long run he
quite possibly made a considerable savings by obtaining a
system that was properly sized and well suited to his needs.

These points, selected from the case studies, are only
a few of the indicators of the problems facing the computer
consumer. The small businessman is in a difficult position
as he attempts to focus on the wide of array of options
available to him. As an adjunct to offering a method by
which the businessman may make a sound decision in this area,

it is appropriate to examine the capabilities and character-
istics of the various system components, as well as exam-
ining some alternatives to the inhouse computer system.

CHAPTER II

This chapter focuses on identifying those character-
istics of a minicomputer system which make it functional
in business applications. It also investigates the alter-
natives available to the consumer in the process of auto
mating the administrative aspect of his business. It high-
lights the basic alternatives, with discussions as to the
pros and cons of each alternative.

Before proceeding, however, the businessman would do
well to ask himself again, "Do I really need to automate?"
In answering this question, one should consider what might be
termed the hard facts of automation. These were pointed out
in the case studies, for the most part.

It is a very rare case indeed that one is able to save
money on direct labor costs when automating. Only when
businesses are extremely large or inefficient in their manual
accounting and other administrative procedures may such a
savings be realized. Savings due to reduction in adminis-
trative personnel are generally offset by the requirement to
hire more highly qualified replacements. Instead, savings
will most often be realized in areas in which actual quanti-
fication of the final result is not always possible.

Once a business has adopted automated procedures, it is
virtually impossible to revert to the manual system again.
To realize the full benefits of automation requires initiative

on the part of top management, as one needs to alter his
orientation in-so-far as standard bookkeeping procedures are
concerned. Such items as ledger cards and similar input/output
media, to a large extent nullify the possibility for increased
productivity. This shift away from hard records poses a
real psychological barrier for the business manager.

The importance of a dynamic, flexible system is often
overlooked. Automated systems in a business environment
tend to grow, it is said "...to fill the existing capability
of any system."[1] The important point here is to recognize
this fact and strive to insure that the system grows in a
direction which is complementary to the business as a whole.

This short list is offered only to serve as a sobering
influence to those who have been bitten by the bug to buy,
but have not seriously considered these points at some
previous time. If the businessman is still firmly convinced
that the road to follow for his business is to automate, he
is then ready to investigate the alternatives. This section
of the report should be prefaced by the statement that since
the operation of every business is such a variable quantity,
there is no fixed answer or package to offer in solving
every businessman's dilema. Each top manager has to inves-
tigate the alternatives and made a decision based on his
knowledge of his business.

2.1 Identification of Automation Requirements

Fundamental to any selection process is the identification

and specification of just what the automation needs of the business are.[2] No matter what approach one may choose, this one step is common to all. It is a highly individualistic procedure, varying not only with the particular needs of the prospective user, but also with the personality of the businessman and how he chooses to formalize or express his needs. A lack of familiarity with the capabilities of computers is a decided disadvantage in this particular area. It does not, however, eliminate the requirement that this particular step be thoroughly thought out and completed in as much detail as is possible in each case. Practically speaking, the manager should enumerate each task that he feels a requirement to automate. Typically, he should think of each task as being a separate entity, or program, that will be developed for the system he will eventually select. A guideline for the specific information required is presented in Chapter III. Another key element to consider is the maximum amount of down time of the system which can be tolerated by the business in regard to each application.

2.2 Inhouse Computing Systems

Having determined, initially, at least, what the automation requirements are, one need next consider the alternatives available. The alternative which will be considered first is the acquisition (purchase, lease or rent) of an inhouse system. For purposes of this report, the inhouse alternatives will be limited to considering a system costing less

than $30,000. For those businesses anticipating larger systems, their needs would be termed as "advanced." It is entirely possible that such a system could be made up of many of the same or similar components as the minicomputer system being considered.

There are numreous advantages to the inhouse system. The outright ownership of the computer offers certain financial benefits to the consumer by allowing him to depreciate its cost over a period of years. If the system is being employed at or near its capacity, the actual cost to the user is considerably less than some of the other alternatives. The lease of a system offers many of these same advantages.

The freedom of scheduling and establishing priorities on one's own system is a big plus. The businessman has greater control over his own system and can rest confidently in knowing that the information he has stored in the system is not readily accessable to outsiders. It would be an oversight not to mention the intangible benefit of sales and customer appeal in doing business with a company that is "going first class."[3]

There are also a number of disadvantages to an inhouse system. These will be covered in detail in the discussions of the alternatives to this type system as being advantages to the alternatives.

For those readers unfamiliar with computer hardware and software characteristics, a brief discussion of the

major system components is included in Appendix 1. This discussion also touches lightly on the selection process, but not to the extent that it is covered in Chapter III.

2.3 Maintenance

All system hardware is subject to a final scrutinization to determine the maintainability of the individual items of hardware. This examination should include the support that may be expected from the vendor along these lines. The importance of maintenance often overrides all others. One may possess the most sophisticated system available and either not be able to obtain or afford adequate maintenance support. Thus, the system is a distinct liability.

The first consideration one must make in determining the level of maintenance required on a system is to answer the question, "How long can I afford to be down?" The answer to this question establishes the basic level of maintenance which is required on the system. Though it is safe to say that limited operations may be continued in all but the worst circumstances, the maintenance factor is still critical.

If the firm can stand to have its system down for only a few hours, then it is forced to obtain equipment or services from sources which can provide this level of support. Often, however, such guarantees are not possible. In such cases (fortunately rare) the only practical alternative is a complete duplicate system available for standby. More often,

allowable downtime is measurable in terms of days. This
permits the businessman a greater degree of flexibility and
opens more options to satisfy his maintenance requirements.
Speaking in terms of 24 to 48 hours, one may contact the
vendor by telephone and have required parts shipped via air
express to insure operational status within the limits. Due
to the modular construction of the systems, it is possible
in most cases to identify, without too much difficulty, the par-
ticular component which is malfunctioning. Often, problems
such as these may be resolved with the vendor over the tele-
phone.[4]

Those problems which actually require the visit of a
serviceman can be very expensive. Maintenance not under
contract often dictates that the user will pay the cost of
the serviceman from the time he leaves his office until he
returns, plus the transportation costs. Those maintenance
agreements which include guaranteed service, if available at
all, often cost from $200 to $300 per month.[5]

The maintenance picture is certainly one which has a
varied appearance depending on who is painting it. Vendors
and salesmen portray it as a very minimum consideration,
while salesmen of outside computer services shade the picture
considerably darker. In actuality, despite its seriousness,
it is something to which one is able to adjust. One needs to
determine how long the business operation can continue without
the services of the computer and then make service arrangements

to adjust to this figure. Consider the cost of the alternatives. Keep in mind that a certain amount of do-it-yourself trouble shooting is certainly within the capabilities of the operators. It requires they closely follow trouble shooting guides and make use of various software routines provided to help isolate the difficulty.[6]

2.4 Systems Software

The selection of systems software is a fairly straight forward process. Again, this selection is based on the intended use of one's system, to include the combination of peripheral devices required. The basic system will include an assembler, in almost every case, included in the base price of the CPU.[7] The assembler is the software package which allows for the conversion of assembly level languages to machine language. As such, it is an essential element of any system. The choices the user normally has to make is between the various operating systems available and possibly the selection of an appropriate compiler.

The choice of an operating system is closely tied to the peripheral devices that will be employed. The operating system controls the allocation of computer resources to include all of the peripheral devices. One must therefore select an operating system which is able to control all devices chosen for the system. In the case of the minicomputer system being proposed, this problem is simplified somewhat. One needs to insure that the vendor is aware of all proposed peripheral

devices, as well as the intended use of the system, so he may offer an appropriate operating system.

A compiler may or may not be required in the system software package. The decision as to whether or not such a package is to be included depends upon the process by which one intends to procure or develop applications software. A compiler should definitely be included if one intends to develop his own software. Also, if software to be developed by an outside source is going to be provided in a particular language, a compiler for that language is required. Vendor developed software, and some developed by third party sources, may be precompiled and provided in assembly language or object code. This procedure may eliminate the need for a compiler, but often complicates the software maintenance aspect of one's programs. For those businesses possessing turnkey systems, a compiler is likely to not be required, as the outside party developing the software will probably have access to compilers required for the existing system.

There are not many alternatives from which to make a selection of a compiler. A report which appeared in the July 1974 edition of "Datamation" magazine reported only one manufacturer which offered a COBOL compiler with their mini-computer.[8] Though there are one or two more at present, the most common compilers remain FORTRAN, Basic and RPG. FORTRAN is the most flexible of these compilers and hence the most likely choice of the three in this case.[9]

2.5 Applications Software

The acquisition of applications programs is of prime concern to every computer user. Expenditures for such programs invariably consume a large portion of the total dollar expenditure for one's system. One must always wonder why, in the case of systems software, which has such enormous capabilities in comparison to many applications programs, costs are often far less than applications programs. The answer is that systems packages have a broader user base than most applications programs. Consequently, development costs are spread over large numbers of users. This same principle is used by many vendors and software development houses in creating a wide variety of general purpose software of a prepackaged nature.[10]

Some vendors are much more interested in assisting the user in the development of software than are others. There are several vendors which specialize in this field-- producing software with a wide variety of user applications.[11] To the small businessman, a vendor with such services should have added appeal and quite possibly receive added consideration in the hardware selection process. A comparative analysis of such a vendor's equipment may well reveal a considerable dollar savings over a system whose vendor provides little, if any, such service. One should be alert to the fact that total software costs may equal or even exceed hardware costs and that savings in this area are equally as important.

Since software is so expensive, often, additional costs are justified to acquire hardware which is either more easily programmable, or to select a vendor who offers the best total package, software included.

Third party developed software is another alternative to be considered. A number of companies provide software development services as well as prepackaged software that may or may not be offered by the various vendors. These companies specialize in selling software either of the prepackaged type or custom tailored to fit a user's special needs.[12] Custom tailored software is very expensive, and therefore, not recommended except in the most extreme case of user needs. Much prepackaged software developed by third parties or vendors is specifically designed to be modified to closely fit the needs of almost any type of business. Occasionally, when searching for a particular program with a service company of this type, they will develop the package to one's specifications and charge a prepackaged rate if the program is one which the company feels will be a saleable product.

Many salesmen stress the simplicity of program writing as a proposed alternative for beating the cost of software development. In actual fact, program writing is demanding and time consuming. Businessmen just do not have the time to become involved in such a project. The alternative of making use of one's administrative help to accomplish this is often a poor choice. Proper training of such personnel

can be both time consuming and expensive. The hiring of a
trained programmer also has the draw back of expense as well
as the presonnel problem of this individual's disposition
after the completion of the given project. Such individuals
demand high wages and seldom are kept busy with routine
program maintenance in a small business environment. An
attempt at inhouse programming often leads back to the vendor
or some third party for software development assistance.[13]
Most emphatically, inhouse program development is not
recommended!

2.6 Turnkey Systems

The turnkey system is one of the most appealing systems
a small businessman may encounter. Such systems may be
acquired through a vendor, or more often through a third
party who will specialize in configuring such systems to
specific applications. The principle advantages of these
systems is the ease of operation, as well as freedom from
software development. There is no requirement to hire
skilled operator personnel, and operator training is minimal.
It is normal with such systems to have scheduled maintenance
services as well as an on-call capability through the company
providing the system. The required software maintenance may
be included in any maintenance agreements established.

It is possible to have such systems developed at the
direction of the businessman involved, but it is a more normal
practice to have the company providing the system tailor the

system to the overall requirements of the business as determined by their experience. It is also often the case that the businessman may have to modify some existing business practices to minimize software development costs.[14]

Often, companies which perform this service are involved with a specific make of hardware, and, as such, the choice is somewhat limited. These companies garner their profits by purchasing hardware in bulk quantities from the vendor and then creating the desired hardware and software packages for given business applications. In these cases, the profits on the hardware may be substantial enough that the company will have little interest in complete software development--a more time consuming venture. Companies which make a practice of this are apt not to remain in business long, but it does warrant consideration.[15]

As with other hardware vendors, never buy such an arrangement from the first turnkey vendor to come through the door. One is able to do a good deal of bargaining with such salesmen, and will do well to openly shop around for the best deal. As previously mentioned, the main disadvantage to the turnkey system is the loss of flexibility. Most businessmen find this a small price to pay for what amounts to hands off operation of their computer system.

2.7 Commercial Time Sharing

One particularly appropriate alternative to the acquisition of an inhouse system is commercial time sharing (CTS).

This is a capability of large computer systems which offers numerous users the opportunity of simultaneous access (or seemingly so) to all of the varied capabilities of that system, much as if it were on the user's premises.

CTS was originally hailed as the Messiah of the computer industry. It promised to provide small business enterprises everywhere, actual access to the massive computing power of the largest computers at a fraction of the cost of trying to buy one's own machine. CTS does in fact offer the user the computing power of the largest computers available at a very nominal cost when one considers the resources at his disposal. It offers the convenience of the computer with few of the problems of running one's own computing center. The requirement for operating personnel is minimized to those personnel charged with preparation of input data. Additionally, it is a method by which the businessman is able to transfer the maintenance problems associated with trying to keep one's own computer operational to those who are in a better position to perform such maintenance.[16]

Another appealing feature is that the companies which provide CTS services normally specialize in assisting the customer in the development of appropriate applications software for the business in question. These companies are able to provide a wide array of prepackaged software, modifications to these software packages, or completely custom tailored applications programs.[17]

Some of these companies also provide comprehensive training to the customer and his employees who will be involved in the operation of the system. This includes complete familiarization with the system as it applies to the user, monitoring of the user's introductory operations to insure sufficient understanding of the operation to preclude disasterous results, classes in programming and assistance in updating existing programs.[18] In contrast to vendor companies who may offer these similar services, the CTS company is generally considerably cheaper for the various levels of service.

CTS allows the businessman the opportunity of automating his business progressively. When one purchases a computer he is paying the full cost of the system from the very beginning. With time sharing arrangements, the businessman may purchase sufficient time to allow him to perform the applications that have been developed and no more. One may create his entire automated system, incrementally, through CTS, and later transfer the software packages that have been developed to an inhouse minicomputer, thereby bypassing the initial runup period. Likewise, one may choose to have his automated system through time sharing while creating his own inhouse system and working out the difficulties which one always encounters during such a conversion. The obvious disadvantage to this is the cost of operating both systems at once. An additional difficulty is the machine dependence of

many programs. Unless programs are developed under rigid constraints, they are rarely portable from one computer to another. Conversion of such programs may be difficult, time consuming and expensive.

Not all applications are appropriate for the CTS environment. Output bound jobs such as payrolls are expensive propositions when performed under a CTS arrangement. CTS is more expensive than an inhouse system if one has his inhouse computer operating at or near capacity.[19] Other limiting features of time sharing include the fact that often during periods of peak use, response time is slow. The time sharing company tries to offset the normal peak demand periods by offering reduced rates at other times and generally trying to educate the user to those times which he should try to avoid. Higher priorities may be placed on special jobs to speed up processing time, but due to the high rates charged for such services, this is only feasible on the most important of tasks.

Additional disadvantages include the fact that the user must provide or acquire his own I/0 devices. Also, though the CTS company is responsible for computer maintenance, it is not responsible for user I/0 device maintenance. The user is dependent upon the telephone company, also, for lines which will allow him to access the CTS company.[20]

Storage capacity is always a critical resource and is no exception with the time sharing company. To reflect the

criticality of this situation, the consumer is charged
substantially for this resource. There are numerous ways in
which a conscientious user may minimize these costs, however.
The better companies will alert the user when his normal
storage to connect-time ratio is out of line from what is
normally expected. Hopefully this prevents inadvertant use
of file space.[21]

Most companies offer an option of how charges will be
made against a particular account and the user is able to
select the one which effectively will minimize his costs.

As mentioned earlier, not all applications are suitable
for the CTS environment. As the time sharing company de-
pends heavily on good will and word-of-mouth advertising,
they are reluctant to accept an account which they know will
eventually terminate with a dissatisfied customer. For this
reason, they will very likely advise a customer of the alter-
natives to specific applications which they recognize as
being uneconomical for CTS operations--from the view of the
customer, as well as their own.[22]

To receive an estimate on the cost of such services,
merely contact the sales representatives of the various
CTS companies and discuss the processing requirements. The
company will provide rate schedules as well as descriptions
of services offered. In comparing rates, one should keep
in mind that the prices quoted by the time sharing company
include only access to the computer and any software packages

that are agreed upon for development. Telephone lines, modems and I/O devices are all the responsibility of the user.

The relatively high cost of CTS services are somewhat offset by the peace of mind enjoyed by the removal of the bulk of the maintenance worries associated with the inhouse system. CTS is especially appealing during the early phases of automation, both in terms of user costs and the availability of trained personnel to assist the user with program development.

Traditional worries the businessman may have concerning CTS include the concern involved in not having complete control of the system. This is partially valid, but practically speaking, the availability of a greater array of computer resources often more than offsets this particular fear. One cause for this concern is a lack of understanding of the time sharing process. More familiarity with CTS will often alleviate many of these worries.

Though communications pose a problem, it is often less than what one might encounter with all of the problems of an inhouse system. The feeling of lack of control over vital information concerning one's company and a lack of trust in knowing that outsiders may have access to such information often turns out to be unfounded. Such access is possible, but most often not practical. Coding and scrambling of information is possible if actually required. The companies which

provide CTS services are involved enough with their own operation that they are generally not concerned with the actual content of customer files. Other safeguards exist to prevent outside access to the wrong files. Though no such system is 100% safe, it requires sufficient effort to access such information that a company need concern itself with this matter only in the most extreme cases of secret information.[23]

The overall impression intended to be communicated in this section is that time sharing should be closely examined by businesses which have decided to automate. It is particularly advantageous to those desiring to automate in phases and wish to eliminate a good deal of the initial trauma involved in the introduction of an inhouse system. An inhouse minicomputer does offer a number of advantages; however, these may be outweighed by the disadvantages when coupled with the possible services offered through CTS.

2.8 Service Bureaus

Computing services provided by a service bureau is yet another alternative the small businessman will be wise to consider as an alternative to an inhouse system. Service bureau arrangements differ from CTS in that the user or customer is not directly interacting with the computer. In actuality, a service bureau may offer CTS arrangements on its computer. Likewise, it may make provision for the input of data by the business in a time sharing mode. The output is

then produced on printers at the bureau. The finished procuct is either mailed or delivered by the bureau, or picked up by the customer.

There are several advantages to service bureau arrangements. Primarily, they are cheaper than similar services performed in a time sharing environment because the bureau is able to actually schedule the given tasks at the time most convenient, as well as the fact that expensive I/O equipment is not required by the user. Many jobs are well suited for this type of disposition. Those which are reoccurring on a scheduled basis, such as payrolls, are ideally suited for this service. Other advantages include the elimination of special operator training and extensive data preparation. Normal practice through a service bureau is to have the bureau prepare data in convenient input form on their own premises.[24]

These bureaus offer the same prepackaged programs and program development services as CTS companies. On the other hand, one is not apt to provide his own programs or have them developed from a third party as might be done if operating in a time sharing environment. Bureaus will, however, modify their prepackaged programs to suit the particular needs of their customers, if necessary. They will also custom tailor software for special applications.[25]

Included among the disadvantages is the fact that turnaround time may be excessive for the needs of the business.

This is especially true when such bureaus are located in
another city, and either input, output or both forms of
data must rely on mail service for transportation. Businesses
which reside close to such a service, however, have a sub-
stantial advantage from the perspective of time delays.

One difficulty often encountered with these bureaus is
the fact that errors frequently occur in the transposition
of input data from one form to another. These difficulties
often do not surface until examination of the output by the
customer. One should realize that the same type problem
exists in all forms of data handling operations by people,
but it is not always so critical as it might be when one has
already had to wait for a considerable period of time for
his output.

The same problems of lack of physical control of the
system and even more serious considerations of confidential
company information exist with service bureaus as might be
felt in time sharing.

All factors considered, however, service bureaus are an
excellent way for small businesses to automate, or at least
begin the automation process. Very favorable service may be
had at minimum cost on a wide variety of applications. The
case for service bureau support is even stronger for those
businesses which reside in close proximity to such facilities
and time delays are minimized. Likewise, the more distant
the bureau is from the customer, the less appeal it is likely

to enjoy. One should still consider which of his tasks may
be suited for such disposition and act accordingly. Even
with an inhouse system, certain programs may be handled more
economically by a service bureau, and one should always be
alert to this fact.

CHAPTER III

Computer system sizing and selection procedures may well be placed in the catagory of an art rather than a science. The case studies in Chapter I illustrated the computer selection process as it actually is occurring or has occurred in four instances. As was pointed out in the discussion of the lessons to be learned from those cases, the common thread which linked all of the cases was the absence of a standard procedure by which such selections are made.

Companies which provide consulting and computer sizing and selection services lack a great deal of uniformity among themselves in regards to methodology. Primarily, their approach is to gain an understanding of the business operation, and then, based on their "feel" for the capabilities of computer systems, attempt to match the appropriate system to the company's requirements.[26] The concept employed here is that it is easier to understand the operation of any given company than it is to develop a suitable understanding of computer systems.

Chapter II developed the importance of conducting a detailed analysis of the company's operations for purposes of determining those areas of the business requiring automating. It referenced Appendix 1 which provided the reader with a general background on minicomputer hardware. From this hardware an appropriate minicomputer system may be

configured. Also, some practical alternatives to inhouse systems were discussed.

This chapter will develop a selection and sizing procedure to orient the manager of a small business in the proper direction to allow him to make a rational decision in the automation of selected tasks in his company.

3.1.1 Selection

The remainder of this report is aimed at businessmen who are convinced they require an inhouse computing system.

It is felt that a sound decision on an appropriate computer system may be made by most businessmen. They must naturally rely on their detailed understanding of their business operation and follow some general guidelines provided to aid in the selection and sizing process. This guidance will be provided in two forms. Initially, an appropriate computer system and components will be outlined which has very general business application. Secondly, the businessman will then size the system to his particular needs by the use of a survey form. This form, when completed, quantifies much of the subjective judgement used by consultants in recommending a computer system.

A general business oriented computer system component diagram is provided in Figure 1. This illustrates those items which have such a wide range of capability that their inclusion in a standard business application package is axiomatic.[27] In this case, the question which faces the businessman is not so much which devices are required, but rather how much capability is required of the devices listed. This will be addressed in Section 2 of this chapter. A brief discussion of the listed hardware will provide the rationale behind the

SYSTEM COMPONENT SCHEMATIC
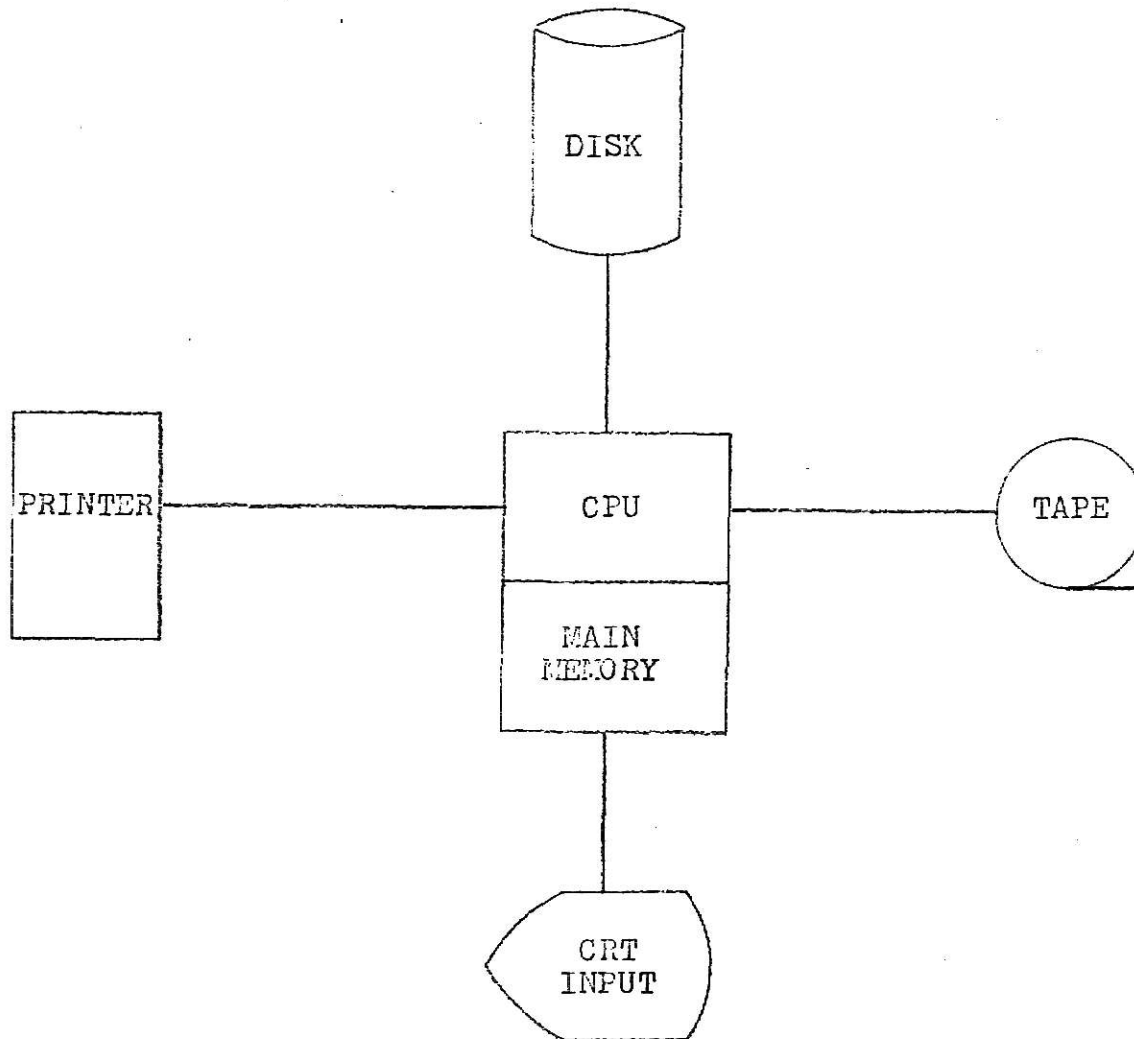

DISK

PRINTER

CPU

MAIN
MEMORY

TAPE

CRT
INPUT

Figure 1

47A

particular configuration given.

3.1.2 Central Processing Unit

Being the heart of the system, the CPU is naturally of great importance. However, the I/O orientation of a business computer allows for a great amount of flexibility in the CPU selection. There is no requirement for exotic computational capability or impressive execution speeds. In this case, any 16 bit word CPU which is capable of simultaneously handling the various peripheral devices will possess more than enough "compute" power to handle all required business applications. The CPU may well turn out to be one of the least expensive items of hardware in the system.

3.1.3 Main Memory

Requirements for main memory will be satisfied in the majority of small business applications within 16K words of core memory. This size of main memory also provides for an opportunity to incorporate a multiprogramming capability into the system, as well as a functional compiler.

3.1.4 Input Devices

An obvious requirement in any system is a means by which the user communicates with that system. The choice of input devices, by both type and number, is a function of the proposed input work load. For a general purpose system, a CRT terminal is recommended. Specifically, a CRT which incorporates a cassette tape for monitoring and editing all terminal transactions, will provide the user with the greatest

amount of flexibility.

3.1.5 Tape Drives

A single cassette tape drive is recommended for purposes of transposing the taped information from the CRT to remainder of the system as required. Also, the cassette tape medium may be used to store infrequently used programs to free disk storage space. The first listed use is its premary function, however. There is little need for a dual tape drive in this proposed system, as the disk drive offers flexibility in this regard.

3.1.6 Disk Drives

A dual disk drive is a recommended element in the proposed system from the point of view of convenient file storage, speed and support of the overall recommendation of a multiprogramming capability. The question as to the type, whether it be a diskette or standard disk drive, may be resolved in Section 2 of this chapter. In the event a standard disk drive is indicated from the analysis, those drives which feature a fixed, in conjunction with a removeable, disk in a single unit, "2-High", are desireable from at least one point of view. That being their relative cost in providing a dual disk capability.[28] A second alternative would be a single standard disk drive with a diskette drive serving the purpose of the second drive. Such a system might be less expensive than the previously recommended device, but would present problems that make it only a second choice.

3.1.7 Printers

The printer, in a business operation, is the cornerstone of the entire system. Its capability effectively limits the performance of the overall system in the vast majority of business applications.[29] Also, the printer, in conjunction with the disk drives will absorb the lion's share of the hardware budget. The selection of the proper size printer will be highlighted in Section 2. Outside of speed and cost, another important consideration is the amount of noise such a device creates in the office environment. A businessman involved in the acquisition of a printer is well advised to consider the proximity of other office workers to such a device in making his final selection.

3.1.8 Systems Software

The efficient operation of this proposed system is a function of the supporting systems software. The operating system recommended, as previously mentioned, should support multiprogramming. This will greatly enhance the operation of the entire system by eliminating the requirement for special off-line input production and provide for flexibility in running application programs.

If the system acquired is other than a turnkey system, a COBOL compiler is recommended. However, such compilers are not ordinarily available, so a FORTRAN compiler is appropriate. Some prepackaged programs may be written in assembly language, but all programs for which the consumer assumes responsibility

should be in a high level language such as FORTRAN. Those
businessmen who acquire turnkey systems need not concern
themselves with compilers,for the most part, as the emphasis
in these systems is on maximum convenience for the user.
In such cases, software is generally pre-compiled and stored
in a ready-to-use status within the system.[30]

Section 2

3.2.1 Sizing

The task of sizing the various components of the proposed system is addressed in this section.

Figure 2 of this chapter is a task analysis form. It provides the businessman a format for itemizing those tasks which he desires to automate. The completion of this form and the indicated calculations will assist the manager in a systematic consideration of the factors of primary importance in determining the requirements for automation of selected tasks in his company.

3.2.2 Task Analysis Form

The following is an explanation of the information required in the various columns of the Task Analysis form:

Column

a. Identification of the task to be automated.

b. Enter the frequency of which the run is to be made; daily, weekly, monthly, etc.

c. Estimate the volume of input data for each task, expressed in the number of characters to be entered each time the task is run. Example: For an inventory update, the average number of characters required in specifying each change, multiplied by the number of changes.

d. If the entry in column b for this task is less frequent than weekly, enter the same value as column c. If

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TASK ANALYSIS FORM

TOTALS	Task to be Automated											
	a.	b. Frequency of Run	c. Volume of Input (characters)	d. Periodic Input Rqmnts	e. Number of Records Accessed	f. Length of each Record Accessed	g. Estimated Total Output (lines)	h. Periodic Output Rqmnts	i. Expected Turnaround Time (days)	j. Maximum Allowable Turn-around Time (hours)	k. Distributed Daily Input	l. Distributed Daily Output

Figure 2.

it is weekly, or more frequent, enter 0.

e. Estimate the total number of records in the file which must be accessed to complete this task. An example of this would be in the case of customer billing, the total number of customers in the customer file. If reference has been made to this file in a previous task, enter a 0 in this column.

f. Enter the length of a single record within each file expressed as the number of characters in the record. It is not necessary to include in this count the number of characters in the labels of the various fields of the records, but merely the information which is entered in the records. Enter 0 if column e is 0.

g. Enter the estimated total number of lines of printed output as a result of execution of each task. Such a figure should include blank lines when required for spacing. Estimate six lines per inch of output. Example: For the completion of an invoice, it may have separate lines for the date, customer name, address, itemized transactions and a total. All intermediate blank lines should be included in the final count. If the length of the form is known, multiply the number of inches of form by 6.

h. If the entry in column b for this task is less frequent than weekly, enter the same value as column g. If it is weekly, or more frequent, enter 0.

i. Enter the normal expected turn around time

expressed in days. If less than one day, enter a 1.

j. Enter the maximum amount of time that the business can continue to operate should maintenance prevent operation of the system (in hours).

k. Enter the value determined by dividing the value in column c by the value in column i.

l. 'Enter the value determined by dividing the value in column g by the value in column i.

After having completed this information for each task which is desired to be automated, determine the totals in columns c, d, e, f, g, h, k, and l.

Table 1 contains a number of computations to be made in conjunction with tabulated values from the Task Analysis form. These computations and their uses will be explained in succeeding paragraphs.

Information from the Task Analysis form synthesizes the computing requirement in general terms. From this information, the size and characteristics of the various hardware components may be estimated. It also aids in the determination of required applications programs as well as the level of maintenance required.

3.2.3 Printers

The Output Planning Figure (OPF), Table 1, represents an appropriate printer speed required for the proposed operation. The computations reflect the normal daily output production derived by subtracting the estimated periodic

TABLE 1

COMPUTATIONS

Output Planning Figure (OPF)=(Total column g - Total column h)/60

Periodic Output Factor (POF)=(Total column g - Total column l)

Required Disk Storage Space=(Total column e x Total column f)/1000 +
(6 x Total number of tasks in column a)

Input Planning Figure (IPF)=(Total column c - Total column d)/24000

Periodic Input Factor (PIF)=(Total column c - Total column d)/(Total column k)

Maintenance Planning Figure= Minimum value in column j

output requirements from the estimated total lines of output.
Based on the consideration of having a printer capable of per-
forming this normal daily output production while operating
at maximum output capacity for one hour, divide by 60 to
arrive at a printer speed in lines per minute.[31] This
figure allows for periodic production slow downs due to
operator absences and other operational requirements. Also,
built in are allowances for daily periodic production peaks,
so long as the Periodic Output Factor (POF) does not fall
below .5. The POF is a factor which expresses the percentage
of normal daily productions relative to peak output require-
ments. A POF less than .5 indicates that periodic productions
make up over one half of the output production, and, as such,
are out of balance with the remainder of the proposed require-
ments. In such a case it is adviseable to have these periodic
tasks performed by other means rather than attempting to
develop a system large enough to handle all periodic work.
Other considerations in printers include the number of char-
acters required on individual lines. Eighty characters
per line should suffice for the majority of printing require-
ments. A standard character set of 64 characters should
satisfy all but the most exceptional requirements.

3.2.4 Disks

The selection of an appropriate disk is principally a
choice between a floppy or standard disk drive and the number
of such devices required. The computation in Table 1 of

Required Disk Storage Space is a planning figure for the number of bytes of storage required (1 character per byte). Division by 1000 of the estimated number of characters of storage converts to KB. The product of 6 times the number of tasks in column a is an estimate of 6KB per program stored on disk. If this figure is below 150 KB, a single floppy disk drive would satisfy the requirement for disk space. However, for backup purposed a dual drive is recommended as a minimum. A dual floppy disk drive arrangement would be suitable up to the point that the KB requirement exceeded 300KB. At this point an additional floppy disk is indicated. Once past the requirement for two floppy disk drives, a standard disk drive becomes a more economical proposition. A single standard disk drive will hold approximately 2400KB. For planning purposes, sufficient disk space should be provided to handle twice the calculated requirement to allow for expansion and flexibility in the use of the system. Additionally, for backup purposes, the dual drive requirement still exists. As mentioned, this dual capability requirement may be satisfied by a 2 High disk or a floppy disk drive.[32]

3.2.5 Input Devices

The type of input device has already been recommended. the quantity of such devices is a function of the Input Planning Figure (IPF), Table 1. The IPF is computed simularly to the OPF. It indicates both the number of devices and operators required to perform the normal daily input operation.

The IPF is determined based on a single operator inputting information at a rate of 3 cps for 2 hours of continuous operation.[33] The 3 cps input rate allows for corrections and other delays. This figure also allows for the overflow from periodic input requirements, so long as the Periodic Input Factor is not less than .5. For IPF values greater than a whole unit, round up to the next higher whole number when the decimal value exceeds .5.

Characteristics of other hardware items have already been discussed. Two major areas remain to be considered: applications software and maintenance.

3.2.6 Applications software

It is recommended that the applications programs be selected from stocks of prepackaged software. Those vendors whose software best fits the needs of the businessman should receive added consideration in the selection process. The list of software requirements may be tabulated directly from the Task Analysis form. For added emphasis, it will be stated again, custom tailored software is the next to last resort for the businessman. It ranks ahead only of inhouse produced programs.[34]

3.2.7 Maintenance

The businessman must seriously consider the aspect of maintenance. This all-important factor in any electro-mechanical system is equally applicable to the computer system. An examination of the smallest figure in column j

of the Task Analysis form indicates both the time and task which specifies the maintenance level. If the smallest figure is considerably smaller than the next smallest figure, depending on the task, an alternate means of performing this function may be sought.[35]

Appendix 2 of this report contains an example of this procedure used to accomplish the sizing of a minicomputer system.

This procedure is intended as a guide to businessmen in general. It is fully realized that not all portions of the guide will be applicable in every case. The businessman should recognize this, also. It is quite possible that a businessman may not understand the rationale for including all of this information in such a survey. If this is the case, he is encouraged to complete the form, in any event prior to contacting various salesmen. It is from information of this type that the salesmen will be able to most directly answer the businessman's questions and requirements. Also, in making such an analysis with the various calculations, the businessman is well on his way to a full understanding of the system he will eventually acquire.

CHAPTER IV

4.1 Future Requirements

The movement of the minicomputer industry toward increased emphasis on applications in small business enterprises, calls for more research in the area of selection and sizing.

The procedure recommended in this report, at this point, lacks emperical testing. Testing is required, specifically, to verify the correctness of the various parameters employed in the sizing equations. Such testing should be geared toward identifying those elements within the basic system which effectively restrict the system's overall operation. The equations have been designed with the most general of administrative applications in mind. One possible direction for additional testing of the proposed procedure is to determine sets of parameters for these equations which would be more applicable to specific business applications.

A number of areas, related to educating and providing guidance to the consumer, exist which warrant additional investigation. Two of these are: requirements in applications software development, and system maintenance. Both of these areas have been addressed in this report, however, they are of such importance and broad in scope, that each is certainly a subject worthy of a report in itself. Another area is that of total system cost estimation.

Total system cost includes hardware, software, maintenance, facility requirements and operator personnel. For a specific application, each of these individual areas take on special importance. It is essential for the businessman to be aware of the fact that under various conditions any one of these requirements may eventually outweigh the remainder in terms of required resources allocated. He must realize that the cost estimated in the system procurement is only a fraction of the overall cost, and will vary widely with each application and installation.

4.2 Summary

This model of a selection and sizing procedure is presented in the form of a proposal. It is intended that the owner or manager of a small business enterprise who feels the need to automate portions of his administration, use this procedure to help him identify the system which best suits his needs. It is designed to help bridge the gap which currently separates the computer salesman and the consumer in the ability to identify those system components which will satisfy the administrative requirements of the business.

It is not, as is pointed out in Chapter II of this report, aimed at selling such a system. Most emphatically, the majority of small businesses will be better off exercising one of the various outlined alternatives to an inhouse system. And, of those remaining, the turnkey system is by far the most logical choice as an inhouse computer system.

The components of such a system, however, may well be identified using this procedure.

The business which has a computer system at its disposal, is in an exciting position. It is important that the businessman be aware of the vast potential of his system. The computer provides much more than the capacity to perform routine administrative tasks. The true worth of such a system is best weighed in its capacity to perform tasks in that business which are as yet undefined. The businessman needs to be consciously aware of this capability, and constantly seeking new applications for that system. He should encourage his employees to do the same. It is for the business which developes a dynamic computing system that the returned dividends will exceed many times over the final cost of that system.

APPENDIX 1

This appendix is designed to serve as an elementary primer on the operational characteristics of minicomputers. It will provide those who are totally unfamiliar with computing systems a minimum background required for understanding some of their basic capabilities and limitations.

A.1.1 Central Processing Unit

The processing unit is the heart of the computer system. It provides the capability of performing data manipulation as well as arithmetic and logic operations of programmed instructions or commands. This unit is able to centrally coordinate the operations of various external devices involved in the transfer of data into and out of the computer's main memory. The primary difference between the capabilities of various processors is the number of machine language commands or instructions to which it can respond. This is referred to as the instruction set. Both assembly language and higher level languages are merely convenient ways for the user to express and manipulate this basic repertoire of machine language commands.

Unfortuantely, the mere fact that a vendor claims a large instruction set does not mean that his CPU will process more efficiently. Some vendors are prone to including in any such count, even the slightest variation of the basic instruction.[36]

Though the true instruction set consists of machine
instructions only, a meaningful estimation of the effective-
ness of the instruction set may be made by counting the
actual number of assembly language instructions required to
program a given operation. Those CPU's which require the
fewest number of assembly language instructions may then be
considered to have an instruction set which may provide
for reduction in main memory requirements.

Basic arithmetic and logic operations are required in
any computer system. In business applications of an admin-
istrative nature, however, there is little use for floating
point arithmetic or other exotic computational features.
The wide range of addressing techniques need not concern
the small businessman, as any system available provides
the capability of addressing all of main memory--some just
not quite so fast as others.

One consideration which is important in business appli-
cations of minicomputers, pertaining to the CPU, and that is
the number of available slots. These slots allow for the
inclusion of an appropriate number of I/O devices in the
system. A sufficient number of slots should be available
not only to satisfy the immediate requirement of devices, but
consideration should be given to future expansion of the system.

In selecting the appropriate CPU for a given application,
one should consider: the number of slots available to allow
for future growth; the efficiency of the instruction set;

as well as the cost of the various processors. A CPU which possesses an especially strong instruction set for a special application will provide opportunities for savings in other areas of significant expense, such as main memory, by requiring less memory to run the same program.

A.1.2 Main Memory

Closely associated with the processing unit is the computer's main memory. This is the internal memory storehouse which holds instructions and data for storage and retrieval purposes for both the processing unit and the input/output control unit. The storage of information within memory is accomplished through a machine coding process. Each word in memory consists of a number of two position switches called bits. These switches may be either On, "1", or Off, "0". By making use of simple arithmetic based on the number 2 being raised to a given power, (binary arithmetic) these bits may be used to represent numbers. These numbers may in turn be translated to special instructions or expressed directly as numbers, depending on the context in which they are being employed. For example, a single bit may be either on or off. It may represent 2^0 (two raised to the 0 power, or 1). If the bit is off, the value of that particular code is 0. If the bit is on, the value of the code is 1. In turn, a 1 may mean yes and a 0, no. Or, the bits may represent the numbers, 1 or 0. Further, the simple fact that the two values are opposites, they may be used as codes for

two more complex alternatives, again, depending on the context in which they are used. Naturally, by linking several of these bits together, one is able to express a wider range of numbers and/or instructions. Normal procedures is to link a specific number of these bits together to form a standard sized "word" within the main memory. The typical word lengths are 8, 12, 16, 24 or 32 bits. The most widely used word length in the industry is 16 bits, although 32 bit words are appearing in the minicomputers being developed, and other sizes are not uncommon.[37]

A valid measure of the main memory capacity may be made by considering the word length in conjunction with the total number of words in the entire storage area. Frequently quoted values in this regard are 4K, 8K, 16K, etc. These figures represent to the nearest 1000 ("K") words the internal memory storage capacity. The values are multiples of two which have been rounded off for purposes of brevity. In reality, 4K is 4096 words, while 16K is 16,384 words. Some manufacturers, however, refer to the storage capacity of their main memories in terms of Bytes (8 bit segments). It is easy to see that a storage capacity of 8K has a wide meaning depending on the base reference, and caution should be exercised in making comparisons.

Other considerations of main memory include the type of construction, whether it is of magnetic core (small magnetic doughnut-shaped rings) or semiconductors. Magnetic core is

more common. It is cheaper and is slower than memories of
semiconductor construction. It is non-volatile in nature,
meaning if power is removed from the system, it retains the
information it contained at the time of the power loss.
Semiconductor memories are faster than core, and are volatile.
This requires a standby source of power if one requires the
retention of stored information after power failures. With
the exception of cost reflecting memory size, none of these
factors is of major importance in the business application
of a single user.

A.1.3 Input/Output Requirements--General

Input/Output (I/O) operations refer to those operations
which involve the transfer of data into and out of main
memory through various peripheral devices. I/O operations
are controlled by the I/O control unit within the main
frame of the computer. This unit responds to signals pro-
duced by the processing unit and the various attached peri-
pheral I/O devices to provide for the data transfer. High
speed data paths are provided within the mainframe, as well
as any number of ports or paths for the transfer of data to
or from memory. The primary differences between computers
in this regard is the speed and number of access paths offered.
With the exception of the number of data paths, these are not
important factors in administrative business applications.
The fact that business applications of computers are tradi-
tionally I/O bound, or restricted for lack of I/O capability,

is not a result of limits within the mainframe I/O control,
but rather of the I/O devices themselves.

There exists a full range of I/O devices. The selection
of these devices is directly related to the specific appli-
cations planned for the system. Traditionally, the business-
man has been concerned chiefly with slow speed I/O devices
such as teletypewriters, card readers, paper tape punch/
readers, line printers and the like. These are contrasted
by other devices which are likely to be less obvious, but
equally as important to the businessman, such as the higher
speed mass storage devices. Examples of these storage de-
vices are magnetic tape, disks, drum memories, cassette
tape and others. It is within this aspect of the system
that the businessman can expect to spend the largest portion
of his hardware dollars. For planning purposes, it is advise-
able to make an initial investment in equipment which will be
able to perform the total input and output operations of
all planned applications in half of the normal work day.[38]
This allows both for comfortable expansion to new applications,
and permits ample time during the normal work day to perform
routine maintenance as well as conducting reruns of appli-
cations which might require such treatment. The following
discussion will dwell on those devices which are felt to be
of most practical use.

A.1.4 Teleprinters

These devices are of similar appearance to an electric

typewriter, and are of 3 general forms: One type employs
the standard typewriter action and has output rates of from
10 to 15 characters per second (cps). A second type employs
a wheel or ball printer, reaching speeds up to 20 cps. A
third such device employs a matrix design for character
formation and may reach speeds in excess of 30 cps. This
third type is considerably more expensive than the other two.
The matrix formed characters sometimes suffer for readabi-
lity. Costs of all teleprinters range generally from $1,000
to $5,000. These devices may be used both for input and
output. They are relatively slow in input capability.
They are restricted to the speed of the typist entering the
data. Practical sustained entry speeds should be considered
to be 3 or 4 cps for input. Another serious shortcoming of
using such a device is that it offers no off-line production
of input data. The entire input operation effectively ties
up the whole system, unless the system software provides
a multiprogramming capability.[39]

A.1.5 Cathode Ray Tubes

The CRT is a device particularly well suited for rapid
display of selected information either determined by or stored
in the system. A typewriter or numeric keyboard allows for
input operations to the system at rates which equal or exceed
the standard teletypewriters. The video screen provides for
editing of such input as well as visual display of output
data. The actual size and speeds of image display may be

considered a function of the device and the operating system. Such data can normally be produced at rates which exceed the average reading speed of the operator. Hence, normal procedure is for the screen to display a fixed amount of information before reacting to a command to proceed. This allows the operator to read the output at his own speed.[40]

The CRT is ideally suited for extracting selected items of information from the system without having to wade through voluminous hard copy records. Speed and quietness of operation are additional factors in its favor. Costs may range from $1000 to $4000 depending on the size of the display screen and other individual unit capabilities and characteristics. The lack of hard copy for either the input or output is a disadvantage for most applications as is the fact that the input capability features no off line production of input data.[41]

High speed, low cost, coupled with noise-free input/output are its major advantages. This device adds another range of capabilities to one's computer system, but may present a problem if hard copy is required.

A.1.6 Cassette Magnetic Tape

Standard magnetic tape drives have been eliminated from consideration due to their high cost. Recent developments in the field of cassette tape drives have made this device a natural selection of the consumer to provide a mass storage capability for his minicomputer system.[42]

The cassette offers the user the ability to store large amounts of information in sequential form at a very small cost. Any time the requirement for stored information exceeds the capacity of main memory, some mass storage system is required. In the case of the small business, and its use of a minicomputer, such a requirement exists almost from the very first run. A mass storage device provides not only a convenient and economical means of storing information, but also storage of applications and systems software packages not currently being used. This, then, frees main memory for its primary function of holding those systems and applications packages currently required for operation.

The cost of the cassette tape drives range between $1,000 and $3,000. Data transfer rates range from 750 cps upward--cost increasing as the transfer rates increase. Those systems relying solely on cassette tape for mass storage require a minimum of 2 such tape drives to provide for copying and other information exchanges between tapes as well as backup.[43]

Cassette tapes may provide for offline input data production through the use of key-to-tape facilities. This feature is offered on special devices similar to teletypewriters and some CRT devices which output on tape, information generated at the keyboard. Once ready for input, the cassette tape may be transferred to the tape drive for input to the system. This greatly increases the I/O capability of the

system, particularly when one considers that output may be made directly to the tape, in many cases, at rates far in excess of printing speeds.

The principle limitation of sequential access storage is the time required to access files on the tape which are not located adjacent to one and other. A search of the entire tape may be necessary to locate the records desired. Much information lends itself to this type of storage, while other files are not so suited. Nevertheless, low cost and high volume storage capability make this a desireable, if not essential, feature of a minicomputer system. A natural evolution of one's system might be to initially begin with dual tape drives with anticipated future expansion to a random access device.

A.1.7 Disk Drives

Like the standard tape drive, standard disk drives are so expensive they will be considered as likely candidates to the mini system of a small business only when the smaller floppy disk drive cannot support the systems operations. The The floppy disk offers the consumer a random access mass storage capability at cost commensurate with the entire system. Costs of such devices vary from $750 for the low end to $5500 for the most sophisticated. Cost is directly related to volume capability and access speeds of the systems. Random access provides for more rapid transfer of information for both input and output. Once the disk drive has been purchased,

the cost of diskettes is not of any greater consequence than are cassette tapes. Like the cassette tape, if a disk is the only mass storage media, two such devices as a minimum are required to provide for data transfer, backup, copying and reorganization of stored information to more efficiently accessable forms. Although the most flexible system would contain dual diskette and dual tape drives, one may operate with one of each. The actual requirement for random access may not occurr until the system has become more fully developed. Certainly as one anticipates the higher speed printing devices and requirements for rapid changes of applications and systems programs, an essential element of such a system is a random access device. Diskettes also feature key-to-disk capability much like the cassette. Such capabilities in either system provide an added dimension to the production of input data.[44]

A.1.8 Printers

The traditional line printer is most often associated with full-sized computer systems and has a "full-sized" price. The cost of a single such device is so high in relation to the contemplated system that this discussion shall be limited to the matrix printer.

The matrix printer offers high speed production of hard copy output for a fraction of the cost of a line printer. As previously mentioned, some teletypewriters are of the matrix design, but these are distinguishable from the larger matrix printers in a number of ways. Principally, they are

considerably slower than the printer. Secondly, the printer
is not used for the preparation or production of input data
as is the matrix teleprinter.

Consideration for the inclusion of the matrix printer
in one's system should be based on the amount of hard copy
output anticipated from the system, considering the amount
of time which can be allotted for this task. If the average
daily output is close to the I/O rate of the teleprinter,
then serious consideration should be given to including a
printer of the matrix design in one's system. Should the
daily output be well below this rate, then such a printer
would be an unnecessary feature.

The prices of matrix printers vary as the capabilities
vary. Those factors which most directly affect the cost of
such a printer include the speed at which the printer is
able to operate expressed in characters per second or columns
per second (one column equals one character, blanks included).
The variety of characters which may be reproduced is also a
factor in the cost. The cheapest matrix printers offer
nothing more than basic numerals, while some of the most
sophisticated offer over 120 different characters. Yet another
factor which increases the cost of the printer is the degree,
or quality of character resolution. Generally speaking,
those printers which offer the larger matrix patterns are
more expensive and of higher quality. This may vary between
vendor's manufacturing specifications and quality control.

Matrix printers, especially those of the non-impact type, are often criticized as being of poor quality printers. In certain cases this is in fact true and one should exercise caution by personally inspecting the quality of output of all printers being considered.

Another factor to consider is whether to acquire the impact or non-impact type printer. If one desires multiple copies of the output data, it is almost essential to go the way of the impact printer. Non-impact systems are much quieter in their operation, thus being more ideally suited for use in a common office area where the noise of other type of printers would cause excessive distraction.

A.1.9 Hardware Summary

This has been a very brief coverage of minicomputer hardware characteristics. As indicated in the footnotes, the bulk of the factual information in this appendix has been referenced to DATAPRO: Report on Minicomputers and the reference, AUERBACH ON MINICOMPUTERS, from the Auerbach series. Both sources are recommended for further reference in this area. Additionally, books listed in the attached bibliography may provide additional background in regard to system hardware.

APPENDIX 2

The following is an example of the recommended sizing
process. It includes a sample system that has been selected
based on the procedure outlined in Chapter III.

A.2.1 Task Analysis

Figure 3 on the following page is a completed Task
Analysis form. It has been completed to satisfy the re-
quirements of a retail sales business.

The tasks listed in column a represent the particular
jobs the manager desires to automate. The payroll is run
on a weekly basis. Input information includes an employee
identification name or number, hours worked regular, hours
worked overtime and other fiscal information such as days
of leave, sick and vacation, etc., for each of 40 employees.
This represents approximately 30 characters of information
to be input for each employee, or 1200 characters. This
value is entered in column c. As the payroll is computed
on a weekly basis, the periodic input requirement in column
d is 0.

Each employee has his own record for pay and other
personnel information maintained on a disk file. Thus, the
payroll requires access to the 40 company employee pay records,
and the figure, 40, is entered in column e. Each record
contains a variety of information estimated to be appro-
ximately 150 characters, entered in column f. One should
recognize that the figure of 150 characters represents only

a. Task to be Automated	b. Frequency of Run	c. Volume of Input (characters)	d. Periodic Input Rqmnts	e. Number of Records Accessed	f. Length of each Record Accessed	g. Estimated Total Output (lines)	h. Periodic Output Rqmnts	i. Expected Turnaround Time (days)	j. Maximum Allowable Turnaround Time (hours)	k. Distributed Daily Input	l. Distributed Daily Output
1. Payroll	wkly	1200	0	40	150	1000	0	1	96	1200	1000
2. Accts Rcvbl	daily	3000	0	800	110	150	0	1	96	3000	150
3. Billing	wkly	50	0	0	0	2500	0	1	96	50	2500
4. Inventory Mgt	daily	1400	0	500	100	100	0	1	96	1400	100
5. Inventory Mgt	mthly	100	100	0	0	1000	1000	2	96	50	500
6. General Ldger	daily	1000	0	50	40	150	0	1	48	1000	150
7. General Ldger	mthly	75	75	0	0	1500	1500	1	48	75	1500
8. Accts Paybl	wkly	2500	0	0	0	1800	0	1	72	2500	1800
9. Order Entry	2xwk	4000	0	0	0	2000	0	1	48	4000	2000
TOTAL		13325	175	1390	400	10200	2500			13275	9700

Completed Task Analysis Form

Figure 3

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the actual information concerning each individual and does not include labels describing that information; else, the figure would be much larger.

In the processing of the payroll, the printed output would be in the form of paychecks. It is estimated that each such check would require printing and/or spacing of 25 lines per check, or 1000 lines of output--entered in column g. Again, the output is on a weekly basis so the periodic output requirements for column h are 0.

It is expected that the payroll will be produced on the same day that the weekly employment information is input. Thus, a 1 is entered in column i. If the computer were to be non-operational, the checks might be drawn up manually on a one-time basis only. However, it would be necessary that the next pay period was performed on the computer, since normal office staff would not be available for repetitive manual production of payrolls when they are not organized to do so. It is then estimated that the maximum down-time that can be tolerated from the standpoint of payroll production is 96 hours.

Distributed daily input and output production are both functions of the number of days allowed to perform a task when the input data required for running a particular pro- are available. These figures are to allow for high volume input and output operations which may be produced on a periodic basis. It permits a realistic determination of

the peak load on the system by distributing the production
of such tasks over the longest time interval possible. Such
tasks as quarterly reports, may have large volumes of infor-
mation to be input, but not be urgently required at the pre-
cise end of the quarter. In such a case, the input may
be distributed over a three or four day span. In the present
example, however, the expected turnaround time of 1 day does
not allow for such distribution. The column c and g figures
are transfered to columns k and l respectively (division by 1).

Similar estimates and calculations are made for each
task in column a. Totals are then taken for columns c, d,
e, f, g, h, k, and l.

A.2.2 Sizing Calculations

Table 2 shows the calculations made to establish the
appropriate sizing values.

The system will be configured around a 16-bit CPU
with 16 K words of core memory. Based on an Output Plan-
ning Factor (OPF) of 128, a matrix printer is selected with
a speed range of from 64 to 200 lpm.

The Required Disk Storage Space calculation of 610 KB
indicates that a standard disk drive is required (610 is
greater than 300). A 2 High disk is selected to provide
for dual drive capability at minimum cost.

A calculated Input Planning Figure (IPF) of .54 rounds
up to 1, indicating the requirement for a single CRT input
device. As recommended, the selection of this device

SAMPLE SIZING COMPUTATIONS

Output Planning Figure (OPF)=(Total col g - Total col h) / 60

    OPF = (10,200 - 2,500) / 60 = 128 lpm

Periodic Output Factor (POF)=(Tot col g - Tot col h)/(Tot col l)

    POF = (10,200 - 2,500) / 9700 = .79

Required Disk Storage Space = (Tot col e x Tot col f) / 1,000 +
                                       (6 x Tot No. tasks in col a)

    Disk Space = (1,390 x 400) / 1000 + (6 x 9) = 610 K Bytes

Input Planning Figure (IPF) = (Tot col c - Tot col d) / 24,000

    IPF = (13,325 - 175) / 24,000 = .54 rounded up to 1

Periodic Input Factor (PIF) = (Tot col g - Tot col h) / (Tot col 1)

    PIF = (13,325 - 175) / 13,275 = .99

Maintenance Planning Figure = Minimum value in col j

    Maintenance Planning Figure = 48 hrs

TABLE 2

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includes the cassette tape editing and recording feature with the CRT.

For reading of this tape to the remainder of the system, as well as storing the lesser used programs, a single cassette tape drive, with appropriate interface is chosen.

The final system configuration includes systems software of an assembler, FORTRAN compiler and suitable operating system to provide a multiprogramming capability. Selected system components with cost figures are listed below:

16-Bit CPU (includes 16 K words Main Memory)	$5500
Printer w/interface	5990
2 High Disk Drive	8000
Control Unit	3000
Removeable Disk Pack	200
CRT w/interface	3750
Cassette Tape Single Drive w/interface	2200
Systems Software:	
Operating System (multiprog)	950
FORTRAN Compiler	100
(Assembler included)	
TOTAL	$29,690[*]

*Figures extracted from DATAPRO 70.

FOOTNOTES

[1] Phillip H. Dorn, "So You've Got to Get a New One," _Datamation_, September, 1973, pp. 45-8.

[2] Edward O. Joslin, _Computer Selection_ (Reading: Addison-Wesley Publishing Company, Inc., 1968), p. 3.

[3] Paul S. Fisher, personal communication, September 1975.

[4] _Ibid._

[5] _Datapro on Minicomputers_, referenced November 1975.

[6] Paul S. Fisher, personal communication, October 1975.

[7] _Datapro on Minicomputers_, referenced September 1975.

[8] L. C. Hobbs, "Minicomputer Survey," _Datamation_, July 1974, pp. 50-61.

[9] Fisher, _Op. cit._

[10] _Auerbach on Minicomputers_, (New York: Petrocelli Books, 1974), p. 59.

[11] _Ibid._, p. 67.

[12] _Ibid._

[13] F. Smith, Boeing Computer Service, Witchita, Kansas, telephone interview, September 1975.

[14] Fisher, _Op. cit._

[15] Carl A. Pick, General Robotics Corporation, Hartford, Wisconsin, telephone interview, October 1975.

[16] Peter Lorenz, United Computer Service, Kansas City, Kansas, personal interview, October 1975.

[17] _Ibid._

[18] _Ibid._

[19] _Ibid._

[20] _Ibid._

[21] _Ibid._

Footnotes Continued:

[22]Ibid.

[23]Ibid.

[24]First National Bank, Manhattan, Kansas, Service Bureau, telephone interview, October 1975.

[25]F. Smith, Op. cit.

[26]Ibid.

[27]Fisher, November 1975.

[28]Datapro 70, referenced September 1975.

[29]Lonnie Graham, Perkin-Elmer Corporation, personal communication, November 1975.

[30]Carl A. Pick, Op. cit.

[31]Graham, Op. cit.

[32]Fisher, Op. cit.

[33]Auerbach, p. 49.

[34]Fisher, September 1975.

[35]Ibid.

[36]Auerbach, p. 26.

[37]Ibid., pp. 5-6.

[38]E. Basham, Kansas State University, personal interview, September 1975.

[39]Datapro 70, referenced September 1975.

[40]Ibid.

[41]Ibid.

[42]Auerbach, p. 51,2.

[43]Datapro 70, referenced October 1975.

[44]Ibid.

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SELECTION AND SIZING OF MINICOMPUTERS FOR ADMINISTRATIVE
APPLICATIONS IN THE SMALL BUSINESS ENVIRONMENT

by

DAVID CHARLES MINSON

B. S., United States Military Academy, 1962

AN ABSTRACT OF A MASTER'S REPORT

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KANSAS STATE UNIVERSITY
Manhattan, Kansas

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This report is designed to assist the manager of a small business enterprise in choosing the most appropriate of the various alternatives available in automating portions of his business. Because of the capabilities of the minicomputer to perform these tasks, the report focuses on the selection and sizing of an appropriate minicomputer system. A theoretical fiscal ceiling of $30,000 has been placed on the proposed system to help limit the scope of the report.

Organization of the report is in four chapters and two appendicies. The initial chapter states the problem and investigates, in case-study format, the actual process by which computer systems have been, or are being acquired. The lessons to be learned from these case studies are discussed following the presentations of the cases.

Chapter II addresses minicomputer systems in general. Combined with the first appendix, it provides the background for a basic understanding of the various components of minicomputer systems, their characteristics, capabilities and limitations. It also surveys a number of the alternatives to an inhouse computer system.

In the third chapter, a minicomputer system is proposed to fit the needs of the majority of small business applications. A simplified method of sizing this system to suit the specific requirements of individual businesses is then presented. The sizing procedure includes making calculations which will guide the consumer to the equipment that will

satisfy his business requirements. This chapter refers to the second appendix which contains an example of the recommended procedure.

The final chapter discusses additional requirements regarding the proposed selection and sizing procedure and briefly summarizes the report.