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RSIC-438

THE IMPACT OF ADP ON THE FUTURE MANAGERIAL ENVIRONMENT

by
Bruce L. Garrett

June 1965

Redstone Scientific Information Center

U S ARMY MISSILE COMMAND
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THE IMPACT OF ADP ON THE FUTURE MANAGERIAL ENVIRONMENT

by

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Prepared For
Redstone Scientific Information Center
Directorate of Research and Development
U. S. Army Missile Command
Redstone Arsenal, Alabama

ABSTRACT

A synthesis of predicted Automatic Data Processing (ADP) developments in terms of their relationships to the total management of an organization, directed primarily to managers faced with a growing demand for better ADP utilization. ADP equipment capabilities likely to be available during the next decade are outlined in detail. Current techniques for the use of ADP systems and problems involved in installing improved future applications are discussed. A timetable is shown predicting the general acceptance and use of applications leading to maximum economical computer utilization. The ADP displaced worker situation is portrayed and actions for its alleviation are suggested. Statistics covering situations where ADP actually displaced workers are shown in graphic form. Managerial approaches to coping with systems integration, personnel training, and organizational structure evolving from an ADP influenced society are presented.

FOREWORD

This document was prepared in response to a request for a general summary of ADP trends indicating anticipated effects on the managerial climate during the next few years. No specific recommendations were requested, hence none are offered. Summarizations and conclusions are the opinions of the author as influenced by factors derived from the bibliography and personal observation.

Literature cited is listed in numerical sequence, by personal author, as it appears in the text. A selected bibliography consisting of 50 references is listed in alphabetical order by personal author.

Material searched for the preparation of this report was limited in the most part to that published since 1960, as much of the material published prior to that time is considered obsolete in such a rapidly developing field. Where possible, discussions were kept general in nature in order to relate ADP to the entire area of automation.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Section I. INTRODUCTION

1. General

The computer as applied to ADP is little more than a decade old and its use has grown so rapidly that some consider it the basis for a second industrial revolution. Our scientific friends tell us that the next 20 years will show technological growth equal to that which occurred in the past 200 years since the industrial revolution.

The first computer utilized for business type data processing was installed by the Census Bureau in 1950; 4 years later the General Electric Company installed the first industrial computer at the Louisville plant. In such a short period of practical application, the computer has profoundly affected all aspects of the socio-economic life in this country because of its speed for processing data and has served as the foundation for industrial automation.

To gain proper perspective of future developments, the history of electronic data processing should be examined in terms of the growth of computer installations, equipment advances, programming developments, and the changing nature of applications and corporate information requirements.

A logical examination of the growth of computer installations should consider both numbers and dollar value. "The data processing industry will have 'its biggest year' in 1965, with annual shipments reaching $1.6 billion for the first time in history, installations of EDP systems exceeding 20,000, and total cumulative value of installed systems in excess of $6.8 billion, according to Honeywell's President Walter W. Finke. He said the rate of increase of cumulative installed systems will start to decline this year as many earlier computers reach the end of their useful life."[1]

As shown in Figure 1, the number of computer installations has increased rapidly to a point where it is predicted that the rate of increase will stabilize near the 1966 level. On the other hand, Figure 2[2] indicates the rate of dollar expenditures, for fewer computers, is expected to continue to increase. This is due to replacement of older computers with more sophisticated and expensive equipment.

Equipment advances are now clearly defined as requirements evolving from shortcomings of early equipment, particularly in the area of input/output devices.

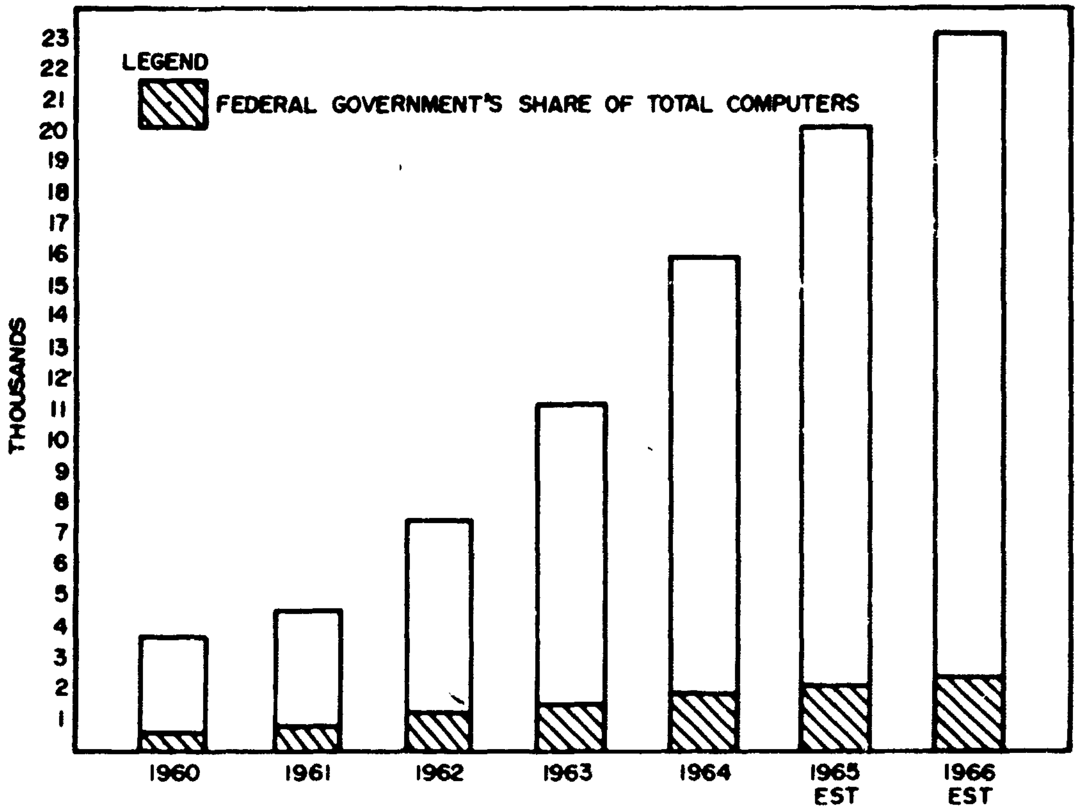


Figure 1. Growth in Number of Computers

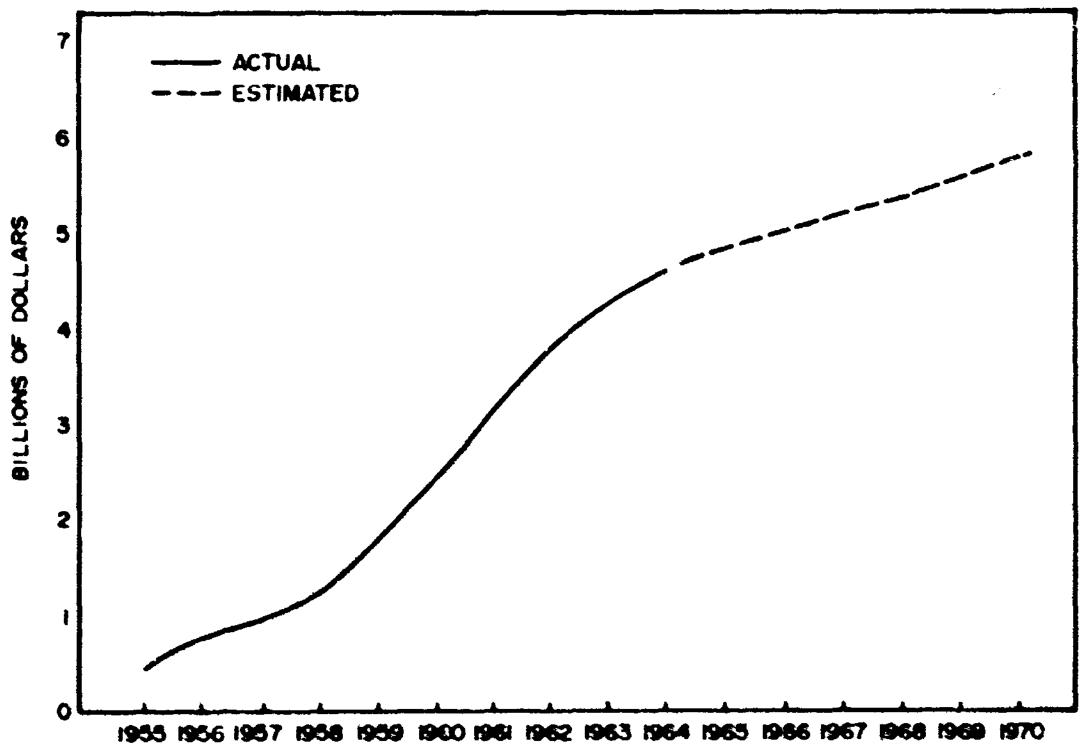


Figure 2 Expenditure for ADP Equipment 1955-1970

The rate of technological improvement has been one of the industry's outstanding characteristics. Despite its short history, two generations of computers, vacuum tube and solid state systems, have already been introduced, and a third generation is now available. These machines incorporate such advanced components as magnetic thin films, tunnel diodes, and microminiaturized circuits, and operate at speeds measured in billionths of a second. These operating speeds compare with thousandths of a second in vacuum tube machines, and millionths of a second in solid state computers. Future computers will perform up to 2 million operations a second.

These technological advances are leading to lower costs per calculating operation. Third generation computers will cost 2.5 times more than current equipment, but will operate 10-times faster. The greatest technological advances will come in peripheral equipment. The development of optical scanners, data transmission equipment, and video display systems will open up new multi-million dollar industries.

Programming developments have lagged behind equipment improvements because initially computer manufacturers believed that given reliable equipment, users would develop and program their own applications.

"The American Computer Industry now functions in a 'technological Tower of Babel,' RCA Chairman David Sarnoff told the more than 4,500 designers, manufacturers, users, and consultants of the computer industry at the opening session of FJCC on 27 October 1964. Whether the computer industry realizes its full growth potential, he said, 'depends in very large degree on the measures we undertake now to establish the basis for orderly development... Neither the operators nor the machines we have built for the processing and transmission of information can yet speak to each other in a commonly understood and accepted language. The means of preparing data, of forwarding and entering data in the machine, and of instructing the machine in its use differ so much from one make of equipment to the next that none can readily accept the product of another.'

"Last year, an estimated $2 billion was spent by American business and government for privately developed computer programs, representing thousands of man-years of effort. Yet, as General Sarnoff says, when a change to new equipment is made, portions of this effort must be thrown away because they have no validity to another make of machine, or they are retrievable only at further cost.

"General Sarnoff did acknowledge that during the past four years, certain essential preliminary steps have been taken toward industry standards and compatibility, largely under the aegis of the American Standards Association and the Business Equipment Manufacturers Association. Representatives of the industry, of users and of technical groups have proposed industry-wide standards in such areas as data transmission, information exchange, and character recognition."[3]

Current efforts include automatic programming, libraries, monitor systems, and software packages, which are discussed in detail in Section II.

The changing nature of applications and corporate information requirements has a marked effect on the use of ADP. Most original applications were only extensions of manual clerical or tabulating operations. As experience was gained with computer use it became evident that the replacement of a few clerks was an almost total under-utilization of its potential.

Economic justification for the utilization of computers is based on the savings effected in such areas as clerical personnel and inventory. Computer usage has led to savings of 10 to 25 percent in clerical costs in many cases, and savings of 10 to 20 percent in inventory costs. The greatest payoff, however, will be in sophisticated total management information systems, employing such advanced management science techniques as operations research and linear programming.

We must recognize that the computer will not just add to our current business techniques, but will completely replace many of them within a few years.

The electronic computer - today's crude precursor of the machine of the future - is important not nearly so much because of the things it does today, but because it represents a new-found human ability based upon the most powerful of theoretical insights into the nature of information and its uniquely important place in our lives.

As this ability is expressed in machine systems that abstract as well as translate documents, help physicians to diagnose disease, enable lawyers to prepare briefs, and assist teachers better to develop the capabilities of their students, the world will become a far different place than it is today.

2. Assumptions

You may have to pinch yourself to realize that over two thirds of the more than $6 billion worth of ADP equipment in use today has been installed in the past three and a half years, and that only a few years ago computer developments which have revolutionized data processing in banking, insurance, transportation, and manufacturing were not foreseen.

a. Assumption Number 1

"That the Federal Government has been and continues to be a major force in the development of the computer industry, and the biggest user of its products, is underscored by the two Olsen reports just issued. The dramatic increase in Federal ADP installations is highlighted by the chart and accompanying comment on Figure 3."[4]

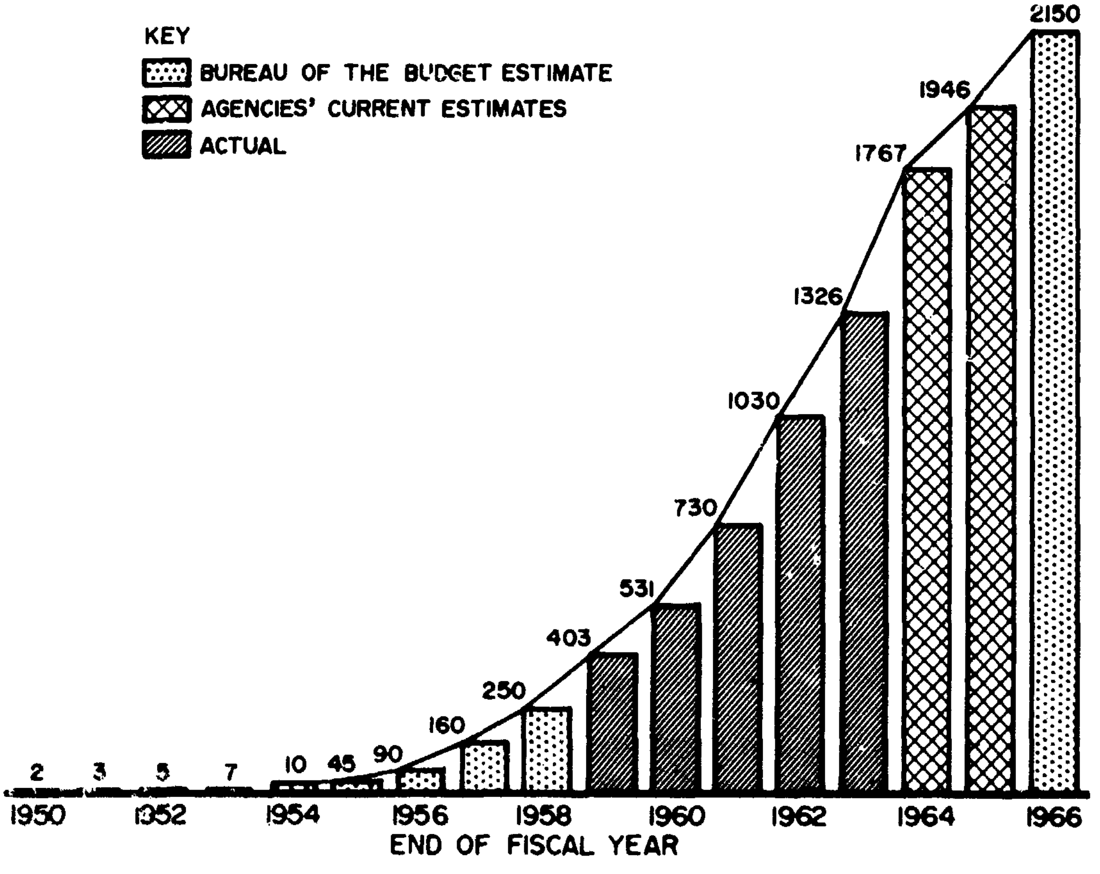


Figure 3. Growth in Number of Computers in the Federal Government

During the early 1950's, uses of computers were concentrated primarily in the scientific area. (Although the first computer for administrative uses was installed at the Bureau of the Census in mid-1950, the use of computers for these purposes did not come into prominence until about 1956.)

In fiscal 1963 there were 1,934 ADP organizational units in the Government, of which 672 had one or more electronic computers. Estimates for 1964 are 2,068 and 798, respectively, and for 1965, 2,089 and 889.

Average utilization of computers in every cost range extends substantially beyond the normal 40-hour week, 176-hour month work schedule, and for the higher-cost installation, extends beyond what would constitute a two-shift operation.

During fiscal 1964, the number of purchased computers increased to 38.5 percent of the total, and an increase to 45.9 percent is anticipated in fiscal 1965.

When each of us first heard about the remarkable new machine, the electronic computer, visions came to mind of a completely automated world. The stories and articles on automation, predictions of the automatic factory, anticipation of the automatic electronic office - all stirred our imaginations. In most of these visions the so-called Push-Button Age seemed to be made possible by the electronic computer.

One could visualize an office in which everyone, by pushing buttons or by some other direct means of contact with an automatic system, could have his paper work done for him and receive any information he asked for from the machine.

Very few of us pictured the present actual scene in most electronic computer installations ten to fifteen years later. No one but the programmer or operator can communicate with the machine, and who can understand them? Something goes on in that air-conditioned, glass-enclosed blue and gray box-filled room, because batches of information keep disappearing into it and printed reports keep coming out of it. But what does go on? And where are all the push buttons? Several girls seem to be occupied, full-time, keypunching cards or tape to be fed into the machine. No one appears to be pushing any buttons or using the computer except in a very roundabout way.

The real breakthrough which must come before the full potentials of the technology are realized is a conceptual one: Managements, especially of large companies, must do a complete job of rethinking the firm's total information system. The objective must be to tie together all operations, no matter how ramified, into one coherent intelligence network that provides immediate sensitivity to changed conditions in any part of the business, automatic feedback and adjustment within pre-set policy limits, and real-time management information retrieval and control where new decisions are called for. Importantly, the thinking must be done imaginatively, with full awareness of impending technical developments.

b. Assumption Number 2

There will be continuing major advances both in hardware and software development. This will include continued improvement in computers and peripheral equipment, further development of real-time systems, continued reduction in computer costs, and improved programming languages and packaged programs.

Automation is perceived primarily as a manpower problem - involving changes in labor requirements, changes in skill as jobs change, and problems of retraining and worker mobility. Managers and workers who have experienced automation in practice know that it is more than this - that it is more often than not introduced to make possible wholly new ways of performing a task, whether that task be controlling a business, a government agency, or passenger air traffic. Automation is all of these things, but my point is that it is much more.

Machines have always been important to us primarily in their role as agents for social change. We use the very term "industrial revolution" not because of the revolutionary machines of James Watt and Richard Arkwright, but because they created a whole new environment for mankind - a whole new way of life. What they gave to history was much more than the steam engine and the cotton gin,. the railway and the power loom. Their machines gave society a whole new tempo, a whole new outlook.

c. Assumption Number 3

That the Federal Government, the Labor Unions, and Business Management will develop an overall training program for the purpose of filling all ADP personnel requirements.

The American economy has always so far been able to fill employment gaps. Now the problem at hand is to develop a large supply of people capable of effectively utilizing the advancing computer technology, people who are trained to utilize the new methodology at or near its potential, the people who will enable rosy industry forecasts to be realized. One can confidently assert that there is going to be a serious shortage of properly-trained personnel.

Section II. ADP MACHINES AND TECHNIQUES

1. Machine Capabilities

a. Technological Improvements

There appears to be great unanimity among ADP users and manufacturers that most mechanical problems that have retarded computer optimal use are either solved or well on the way to solution.

As remarkable as the progress has been in computer technology over the past decade, industry experts regard computers at the same stage of development that automobiles were when they began to be generally accepted by the public. Advances in the state-of-the-art will bring third generation computers employing thin films, cryogenics, microminiaturization and tunnel diodes.

"We can expect the following developments in computer systems design:

1) "The physical size of systems will continue to decrease with the introduction of integrated circuitry, and the switch from electro-mechanical to electronic I/O devices associated with the computer.

2) "Micro-electronic components will probably become cost-competitive with standard logic circuitry by the mid 60's, causing substantial repercussions in the structural design of medium- and large-scale computers. The first generation micro-logic computers may lean towards more mechanization of programs in hardware, and computers with FORTRAN-type and ALGOL-type logical packages may be an early development. However, by the late 60's this trend will be reversed as the applicability of micro-electronics is better understood and becomes extended to memory design.

3) "Parallel, modular computer systems, iteratively built up from a standard set of logical processor modules, I/O devices, and memories, will become the basic system of the late 1960's. The relatively simple modular logical processor will allow for far more flexibility on the part of computer manufacturers, more homogeneity in the hardware, and the beginnings of a catalog approach to computer purchase. The distinction between small, medium, and large systems will be largely eliminated, and applications will be designed primarily on the basis of the number of processors, memories, and I/O required. Standardization in the industry will further limit the number of languages and hardware configurations available.

4) "There will be continued development of higher-level programming languages and executive routines, making the computer more accessible to the user. This closer man-machine interface will be further enhanced by the availability of displays, permitting continuous discourse and exchange between the man and the machine. This will also permit the application of open-ended programs, which operate on partial data, or incomplete and poorly detailed procedures.

5) "The mid 1960's will also see the emergence of very expensive computers renting for $150 to $350 per month. These units will be general-purpose stored-program digital units, similar, in many respects, to the logical-processor module used in the larger systems. The system will not have to be very fast since it will be primarily used as a (vastly more efficient) desk calculator with a stored-program memory. In most applications, the system would not preprogrammed, with a keyboard for entry of data and for the call-up of fixed subroutines. Four-address-instruction format with floating binary-coded-decimal capacity will probably be used for simplicity of programming at the expense of efficiency.

"These systems will be used in such varied applications as:

1) Maintenance of accounts and order processing in a small manufacturing firm or large retail store

2) Production planning and control in a small job shop

3) Engineering calculations in a small scientific lab, where a large computer is not economically feasible or easily accessible.

"The late 1960's will also see the emergence of direct digital control systems, characterized by small word lengths (10 to 14 bits) internal analog-digital converters, and specialized operational codes. These devices should prove economical and competitive for the control of processes of 30 loops or larger, as compared to general-purpose digital or analog systems. Batch-sequence control systems, applicable to normal batch-sequence work, assembly-line control, automatic checkout, etc., will also be developed. These units will be character oriented, and will have extensive logical and bit manipulation ability but almost no arithmetic capability.

"These devices will be installed in the process manufacturing industries, and will replace both the general-purpose process control systems and many of the analog devices now being used in these areas."[2]

ADP devices and concepts, which were inconceivable even in the minds of scientific fiction writers a few years ago, are continually emerging.

One example of this is the cybertron, a computer which does not have to be programmed, in the usual sense of the word, to do a specific task. Rather, it goes through a learning period quite like that of a child. After the machine is taught the correct responses for certain sets of stimuli, it can give the correct responses when faced with these circumstances again. The cybertron has been taught to distinguish between real and false target echoes in sonar operations, and it compares favorably with human operators in this endeavor. It will soon be taught to evaluate data from electrocardiograms.

Another example of the highly advanced systems which research into human processes is making possible is the perceptron, a pattern recognition device. The perceptron distinguishes between different letters of the alphabet and it can recognize faces and other objects.

In communications - the laser, a new component, which is the result of study in electronics and optics. The laser makes possible an entirely new means of long distance communication through storage of electronic energy in a crystal, discharge of that energy as a burst of light so well modulated that it can be converted back to an intelligible telephone conversation between men or machines. When great increases become possible in speed of data storage and retrieval, this is called cryogenics or ultra low temperature electronics. An incredible phenomenon (molelectronics) is a substitution of the structure of the molecule itself as electronic circuitry in place of the subminiature component circuitry that is today considered the most advanced of methods.

An experimental, general-purpose fluid-operated digital computer was recently demonstrated in New York. This computer was operated entirely by channeled air flowing through molded plastic switching elements, completely free from dependence on internal electrical impulse.

Not only speed and capacity, but reliability of automatic computers has also been multiplied by a factor of tens of thousands. Reliability has increased to a point where a billion to ten billion operations take place without errors. In addition, automatic checking has been built into computers, so that the release of wrong results is virtually an impossibility.

With fantastically increasing computational speeds and memory capacities, more rapid information access and faster print-outs, the problem of computer input becomes the glaring bottleneck. The banking industry has taken giant strides since 1959 in making original documents talk directly to the computer system after agreement on the magnetic ink as the activating vehicle, and upon a standardized character configuration.

One advantage of technical advancements has been that computer costs as related to computer performance have decreased. Equipment today costs half as much as equipment that was available 6 years ago with approximately the same internal capacity.

"One of the most important factors in the cost of a computer is the unit cost per calculating operation. As the price of a computer goes up, the cost per calculating operation goes down. For the most expensive computers, the cost is least.

"Tremendous increases in the ratio of computing power per dollar have been made in the last 2 years. The total rental of current machine installations is in the area of $ 73.9 million a month; and these machines in total can perform 108 million operations per second. When the operating ability of the installed machines is divided by total rental costs, a measure of computer power is available which can be used as a basis for comparing the advances made in computing power per dollar. On the basis of statistics, today's theoretical computing power per dollar ratio is 1.46, which is a 155 percent increase over the ratio of 0.57 in 1960. Expressed in another way, through-put speeds have increased at the rate of over 40 percent a year. As computing power per dollar continues to increase, more and more companies will find it economically feasible to invest in million dollar computers."[5]

There will be a significant reduction in the use of punched cards starting in the 1967-1968 time period. This reduction in the use of punched cards will result from such developments as (a) direct input to the computer system through several purpose data collection and data input devices the use of which will become economical through communications developments; (b) selective output and inquiry from a carefully structured corporate "data base" immediately accessible through random memories in the hundred billion bit range; and (c) use of optical character recognition to replace keypunching.

Centralization of main computer activities will be a marked characteristic, with local activities serving largely as input and output stations. This will come about through the development of a variety of special purpose, industry-oriented input devices.

Image files will be the major new technological area to be incorporated into the corporate information system. This will begin to take place on a reasonable scale around 1968, but will become an integral part of most systems as reusable film becomes economically available after 1970.

The Research Program determined that the use of photo image files will be important from the following viewpoints:

1) Together with other developments, such as display, it will be the basis for a second major revolution of company engineering activities, through the introduction of automatic drafting.

2) It will significantly reduce the use of pre-printed forms, since data and format will both be produced by the systems output.

3) It will revolutionize technical research by making available on an inquiry basis full information on references on any technical subject that has been provided for in the system.

Mass random access memories, both digital and photo, and communications will be the two major areas of development. These will result in centralized data banks containing the total files of a corporation. These files will be in the 10 and 100 billion bit capacity range, with cost per bit of 0.01 cent. They will be accessible on a remote inquiry basis throughout the company and will be structured so as to minimize delays in answering inquiries that today are caused by programming problems.

The average, large scale systems, by 1970, will have the following characteristics that differentiate them from existing systems.

1) They will be real-time information systems.

2) They will include graphic elements, display systems, facsimile and large files in the 10 to 100 billion bit range.

3) They will be communications-oriented, with the cost of the central computer being less than 30 percent of the total system.

4) In many cases, they will be industry-oriented, or tailor-made for the industry on the basis of special purpose peripheral equipment.

Voice response from a talking computer has recently made its initial debut when the American Stock Exchange installed an automated telephone quotation service that features a computer system which transforms digital signals from an updated on-line memory into a limited speech vocabulary capable of answering 72,000 inquiries an hour without a busy signal. Many technical problems require solution before a computer can voice reply to an inquiry requiring a search of a variety of stored information from which a logical answer is compiled.

Paper-thin silicon circuits, no larger than a lower-case letter "o" on a typewriter, are chemically processed to perform the complete logic functions of a handful of the transistors, diodes, and resistors used in "second-generation" computing systems. The microminiaturized integrated circuit shortens the paths between logic elements - greatly increasing the speed and relaibility of computation and eliminating thousands of interconnections. Each of these remarkable small devices contains the equivalent of 15 transistors, 13 resistors, and the necessary wire connections found on conventional solid-state computer circuit boards.

"The character and pattern recognition field will experience major growth within the next ten years. However, the optical character recognition field is still in its infancy. After more than 5 years of research and development, it is still not feasible to read any arbitrarily selected typewritten document. The recognition of handwritten characters on a production basis is even further away. Character recognition developments can be classified into four major categories or approaches.

1) Stylized-Font Readers - This category includes magnetic and phosphorescent inks, specially shaped characters, cut characters, etc. These systems are characterized by using two character representations: one which is read by humans and the other which is read by machines. There are many variations to this bi-lingual approach but their applications are fairly limited. This approach is the simplest of the four.

2) Fixed-Font Readers - This approach includes template matching peepholes, threshold function weighting schemes, etc. These devices generally use some sort of masking techniques, either optical or logical, and perform the equivalent of correlation analysis of unknown characters to a stored library of recognizable characters. These systems are more flexible than the previous type, but are restricted to a few type fonts at present. More sophisticated versions of this class of system use diagram and word structure to resolve ambiguous situations.

3) Topological-Properties Readers - This class of system is based on connectivity and geometric characteristics of characters such as inlets, outlets, cups, caps, horizontals, verticals, crossings, etc.

The elements of each character to be read are analyzed and these characteristics are then determined and identified through the use of electronic logic circuits. These systems are capable of handling a wider variety of correct (noise-free) fonts, but are troubled by specks or breaks.

4) General Adaptive Character and Pattern Recognition Devices - These devices function as self-organizing systems which intrinsically "learn" the properties of various fonts presented to them, abstracting from these the successful recognition criteria. This type of system is still primarily a laboratory device but offers the greatest flexibility for the future. It is the most complex approach of the four.

"We should begin to see material improvement being made in the efficiency of character recognition equipment in the years 1965-1968.

"By 1970 we forecast that military impetus and the basic needs of the data processing industry will force the development and introduction of character recognition equipment which can process random typewritten documents and most printed material produced from known type fonts of standard size.

"Large screen and console type displays will come into their own, in the coming decade. Many of these devices were built to satisfy military requirements in command control and intelligence applications but they are equally applicable in industrial management information systems. Console displays (generally an alpha-numeric cathode-ray-tube unit) take alpha-numeric and graphic information from a digital computer, providing a buffered input/output link between human operators and a digital processing system.

"Large-screen computer-generated display systems fall into four basic types:

1) Electromechanical Displays - These are based on either a rotating disk, on which a series of symbols has been preprogrammed to be called up on command, or some type of stylus inscribing a picture on a semi-opaque medium through which light is projected.

2) Slide Projection Display Systems - In this system, a slide is generated through electronic writing techniques, processed rapidly (from 5 to 30 seconds), and then projected on a large screen.

3) Refraction Display Systems - In this approach, deformations or ripples are formed in a Schlieren medium by the bombardment of electron beams from a conventional electron gun. These deformations

produce refractions, causing light to pass through an optical grating or set of diffraction bars to a screen. These variations create patterns of light and dark which are used to create the display.

4) Matrix Display Systems - This system uses a matrix of X and Y lines which are pulsed or triggered to produce a two-dimensional display pattern.

"Continuing military requirements will result in further developments in large-screen display devices. Slide-projection displays appear to be the most reliable, and easiest to maintain, and will probably be used to satisfy most industrial requirements. Matrix display systems will probably appear as production equipment by 1968-1970. At present most of the matrix displays have been based on the technique of electroluminescence and have only been produced as laboratory prototypes.

"We also predict the appearance of three-dimensional display systems in the 1966-1967 period. Experimental versions of such devices have already been developed.

"Most of the printing systems which have been utilized in data processing over the last ten years have been electromechanical. However, the next ten years will see the development of a wide variety of printing and copying units based purely on electronic techniques. One example of this new trend is the number of digitally-oriented microfilm printers which have been announced within the last two years. These devices take the output from a digital computer, generate a tabular array or image using a cathode ray tube, and produce a microfilm slide of the image presented on the tube face. Improvements in image accuracy, precise positioning on the tube, and new developments in the optics of the photographic system can be expected. Using the slides or film produced from these devices, it is possible to prepare high-quality offset plates for large-volume printing.

"We can also expect dramatic new improvements in the field of electrostatic and Xerograpnic copiers. Office photo-copying and microfilm equipment will be developed as integrated elements of a total information processing system, by the end of the 1960's." [2]

Until recently, data collection and transmission equipment have been manufacturers oriented Standard devices have only recently been made available for automatic control and processing of multiple message channels. Through the 1950's most data transmission was over telephone or teletype lines. However, new equipment coupled with digitally oriented communications links have made digital transmission practical.

The American Telephone and Telegraph Company expects communication between machines in different cities to exceed voice communication over telephone lines by 1970.

"We do not see any major technological breakthroughs in data transmission equipment in the next five years. However, there will be continued modifications and improvements in present equipment. Better error detection and correction features will be offered; line signaling and equipment synchronization problems will also be materially reduced. Digital communications services supplied by common carriers will also improve as the number of subscribers increases, and more efficient switching and store-and-forward systems are installed.

"We also expect a variety of new data-transmission-oriented remote-collection terminals, including such items as keyboard printers with data buffers, card and stub readers, paper-tape and document readers, and magnetic-tape input and output devices. Voice encoders will probably also appear for limited applications by 1968. Perhaps the most important new development in data transmission in the next ten years will be the extablishment of a universal transmission code. The American Standards Association's X3. 2 Subcommittee has proposed such a code, which will probably be approved in its present or modified form.

"There will be three major directions in the application of data transmission equipment:

1) Remote-Inquiry Data-Processing Applications - These will be using a central computing facility, tied by data transmission links, to remote locations or inquiry stations.

2) Computer-to-Computer Data Transmission - This can be used for load balancing, information transfer, and more efficient use of multiple computer facilities.

3) Store-and-Forward Communications Processors - These will control the flow of both data and administrative messages from a central computer processing facility or remote station, to a large number of other remote stations."[2]

The multiplexer or communication terminal will provide the heart of advanced integrated computer-communication systems within the next few years. Multiplexer systems will control up to 400 communications lines at speeds in the 5000 character per second range. The multiplexer can be programmed to recognize incoming and outgoing transmissions and automatically route the data to the appropriate data storage, data processing, or output device.

These and many other devices now under development lead us to believe that the future is already here. Some of the devices appear to be destined for further development and appearance on the ADP scene within the next few years. Figure 4[6] shows a projection of availability of new developments for general systems use.

b. On-Line, Real-Time (OLRT) Systems

Improved machine capabilities have provided the means for realization of the integrated systems dream which has so consistently eluded managers since the inception of ADP. The realization of total integration of the management system of any organization is dependent on two basic machine capabilities. One, a very large, high speed, random access data storage device; the other, an actual OLRT capability. Since the data storage device is generally well understood, but some confusion exists as to the full meaning of OLRT, it seems desirable to attempt an explanation of the system.

"In a total OLRT system each and every person, machine or point (point of origin) in the organization using the system, having a true requirement to originate, retrieve or utilize information, is provided with a point-of-origin device (POD). These devices are connected to a central data processing complex by wires or other direct communication links (refer to Figure 5).

"Each device permits two-directional information flows at a point of origin of information such that the person or machine using it receives responses to his requests (when a response is required) in the amount of time desired. This, obviously, implies that all information with which every person or machine must deal is stored in some mechanized form immediately accessible to the data processing complex, and that all files of such information are connected on line to the complex.

"The total nature of the system is brought about by the fact that all information for every person from the chairman of the board down to the lowest clerk is inserted and is available through the point-of-origin devices. This means that all information for all system functions is processed and stored by the system.

"In addition to persons, machines, and points within the organization, it may be desirable in some cases to go outside the organization to the true original source of information generation and place point-of-origin devices in the environment of the organization."[7]

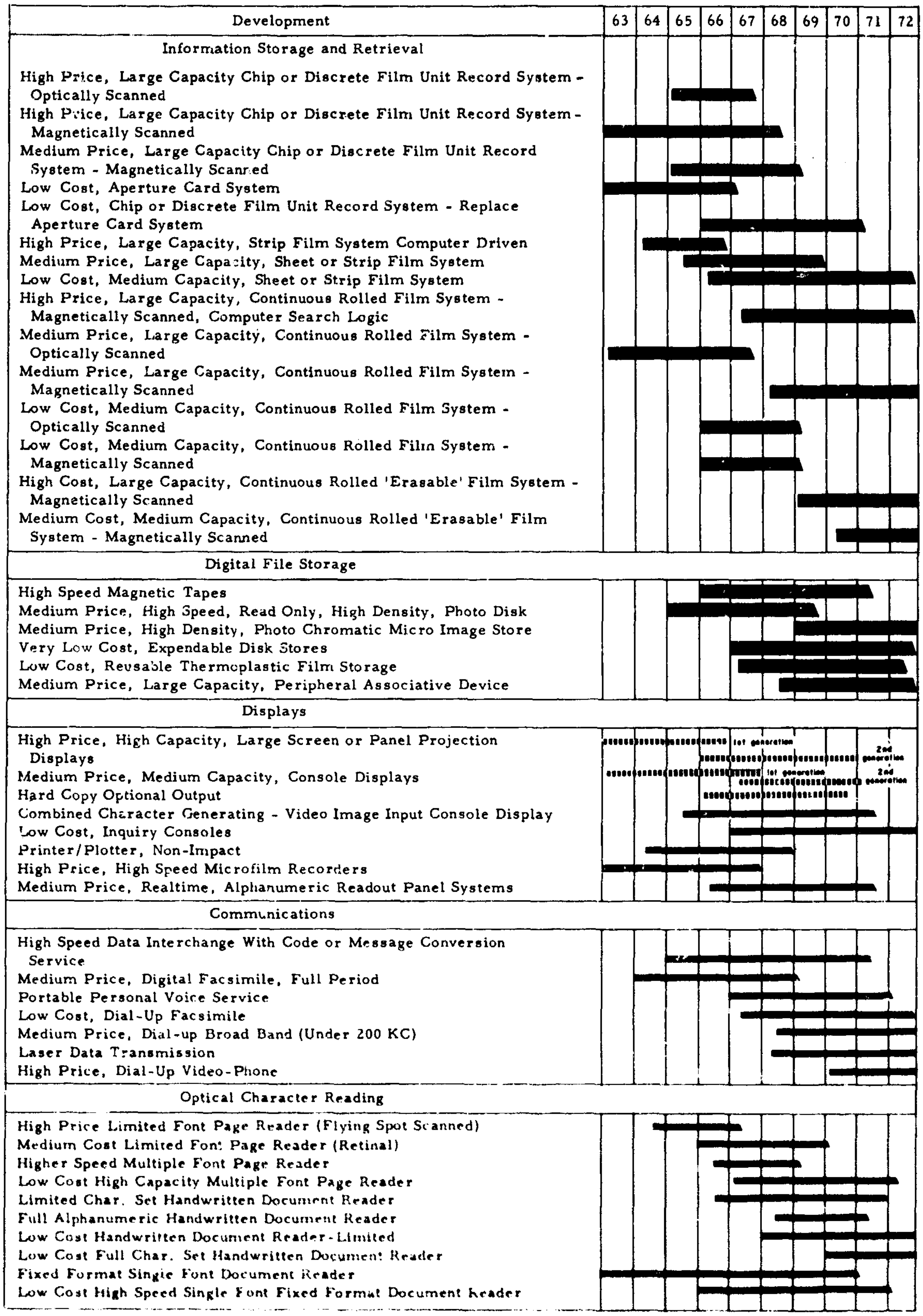


Figure 4. Projection of Availability of New Developments for General Systems Use

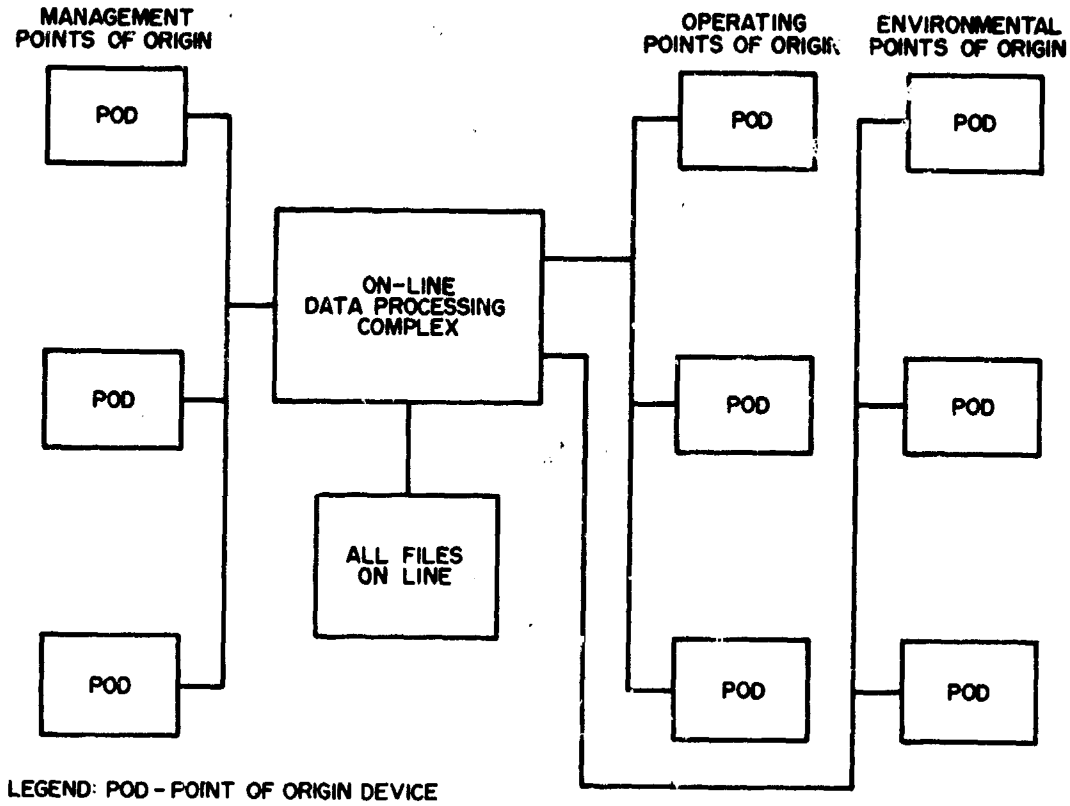


Figure 5. Total On-Line, Real-Time Systems Diagram

c. Third Generation Equipment

The next major improvement in the ADP field will be the widespread use of the third generation of equipment. The following is an attempt to explain this equipment in terms of today's availability. Figure 6[6] shows a comparison of systems evolving through the three generations.

Third generation, large-scale computer systems may employ more than one processor to process many programs simultaneously through a time-sharing system. Such time-sharing systems will result in greater processing capacity, and the ability to handle a variety of problems at the same time. Complex system switching arrays will permit switching a program or parts of the system to peripheral processors under program control or processor control.

These large-scale systems will cause a general trend toward centralization of computer facilities. Priority assignment of data

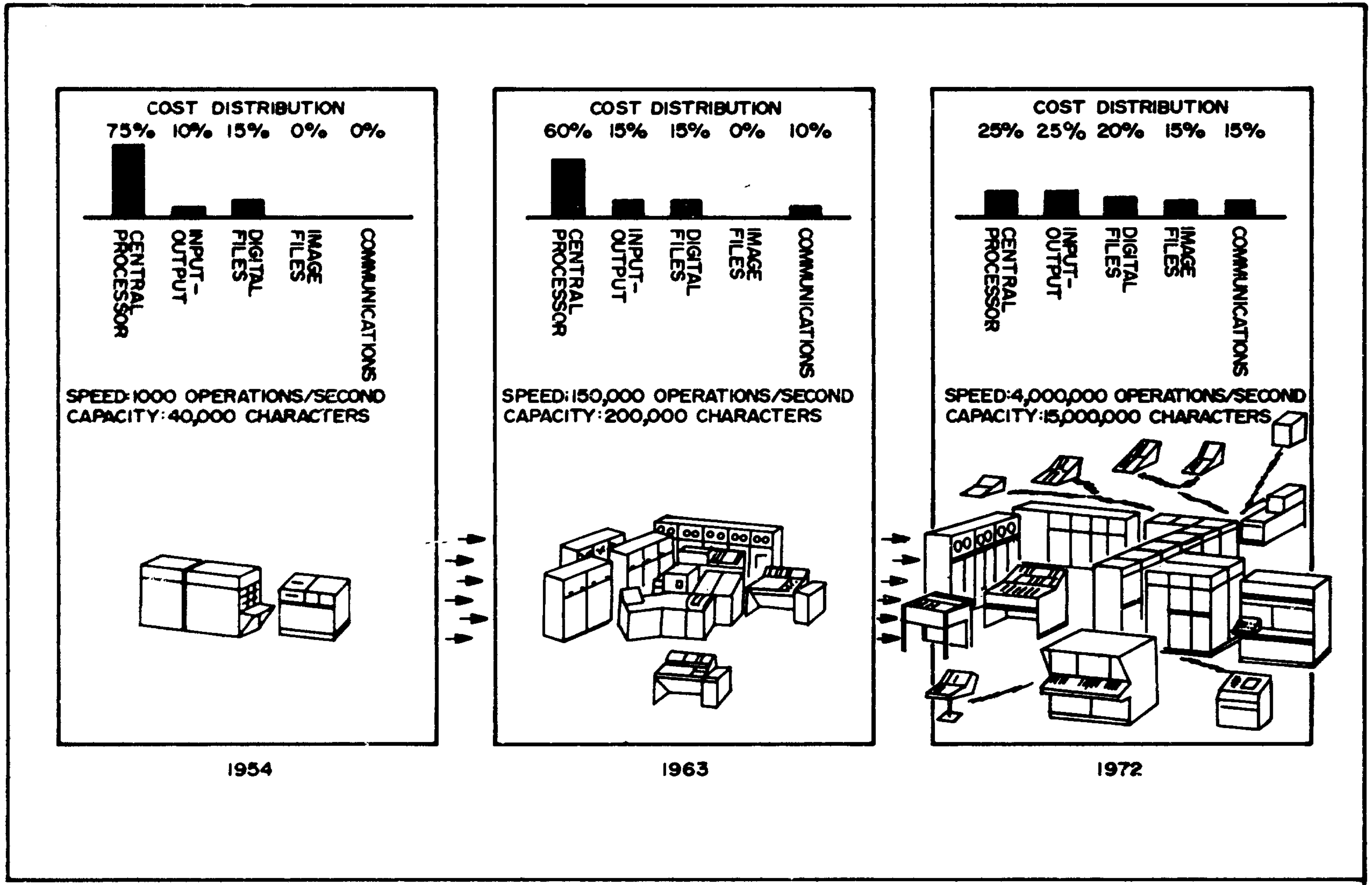


Figure 6. Systems Evolution

received through communication links will allow the simultaneous use of real-time and batched processing. High priority data processing will go through on a real-time basis; lower priority will be batched for processing in slack usage periods.

The new systems will include a substantial amount of directly addressable random access storage. Associative memories will complement the large working storage. Most of the medium- and large-scale processors will have list processing capability. Sophisticated techniques for list processing are now under development. In addition, provision can be made for processing in a preferred sequence through what is termed "stack list" processing.

A primary characteristic of the third generation systems market will be a large reduction in throughput cost. Savings of 50 percent or more can be expected as a result of higher input, output, data collection, and processing speeds. Data will be organized in a format for display or print-out thus reducing output time.

The primary mode of operation for most third generation machines will be binary, although the programmer will deal with the machine in a character format. The efficiency of fixed word, single address systems will reduce throughput costs, requiring better and more costly software.

Most large- and medium-scale machines will use a fixed, 48 to 60 bit word. Image instructions will become part of every system's repertoire. Using large memories, images may be collated, sorted, modified, and stored.

A mixture of standard and micro-electronic components will be used for arithmetic and control although integrated circuitry is viewed as a possibility for machines appearing at the end of the decade. High speed "scratch-pad" memories will be used to speed up instruction execution time.

A greater number of index registers will be provided and indirect addressing will be universal.

Nearly all systems will have priority interrupt hardware for real-time operations. For effective use of such hardware, the following features will be employed:

1) High-speed memory dumps into auxiliary storage
2) Memory lock-out feature to protect stored programs during program development

3) Rapid interrupt service
4) Control of access to memory for systems components.

Several technologies offer large-scale memories with millions of words. The use of optical character recognition devices will play a significant role in developing new ADP applications. As page readers are developed and become more sophisticated the number of applications will increase dramatically.

Optical detection of handwriting will not be available in the next generation. Experts disagree on this subject but one prominent authority in the field has predicted that two decades will pass before optical scanners will be able to read full alphanumeric handwriting economically.

d. Characteristics of Third Generation Computing Systems

(1) Memory Characteristics. Because of cost and storage needs, the system of the future will provide multi-level memories with fixed cost-speed ratios. All memories will be fixed word, binary, single address instruction, potentially standardized at 48 to 60 bits with checking, and full character manipulation ability.

(2) Memory Types. The memory types are as follows:

1) Scratch pad memories used for registers and high-frequency data or iterative loops; 100 to 1000 words; 150 nano-second access; thin film, or other

2) Program memories used for program arrays, and real-time control; 1000 to 8000 words; 150 to 250 nanosecond access; thin film

3) Major core memories for frequently accessed mass data storage, in excess of one million words; 1 to 5 microsecond access; core

4) Large-scale, auxiliary random storage for real-time data, up to one billion characters; 5 to 10 millisecond access; drum file, disk-file or photo-storage.

(3) Features. The features of the system are listed below:

1) Fifteen to sixty-three index registers
2) Image processing instructions
3) Real-time information display

4) On-line remote data communications
5) Message switching
6) Up to 53 priority channels.

(4) Input/Output. The input/output capabilities of the system are listed below:

1) Voice input is a 2000-word vocabulary.

2) Optical character recognition is page reading with limited multi-type font capability at 2 to 3 pages per second and 200 to 500 characters per second.

3) Card reading is 1500 to 2000 cards per minute.

4) Card punching is 350 to 400 cards per minute.

5) Paper tape reading is 1000 to 1500 characters per minute.

6) Printing is 1200 to 1500 lines per minute (Impact).

7) Printing is 4000 to 8000 lines per minute (Non-impact; off-line).

8) Magnetic tape density is 1000 to 1500 characters per inch.

9) Speed is 75 to 400 inches per second (continuous).

10) Transfer rate is 75,000 to 600,000 cps.

(5) Conclusion. Recently, a list of over six hundred computer applications was published by a data processing publication. Third generation computers will multiply that list several times. Large memories, higher speeds, and an increase in input-output sophistication will enable the user to apply ADP to many areas of operation that were hitherto impossible. The rate of expansion in scope will probably exceed the rate of expansion in volume. Third generation computing systems will be used to integrate many diverse business operations. Through the use of mathematical models and simulation, the computing system will aid in the planning function. Through the use of an integrated system with visual display and real-time operation capabilities, the computer will aid in the decision-making activity. In addition, the third generation system as part of a totally integrated information system will assist in the control function.

2. Techniques for Use of ADP Machines

ADP device development and new techniques for their use seem to reciprocate. On one hand a business demand forces the development of a machine in order to cope with an increased volume of work, on the other a new device that may have resulted from the experimentation can be adapted to an entirely different kind of work. A most significant breakthrough in recent years is the development of devices to enter source data directly into the computer, thus breaking the source data preparation bottleneck. This development coupled with remote point-of-origin devices and improved communications open the door to many new and useful ADP applications.

Extension of computer applications will come with increased emphasis on real-time systems. In the next decade direct communications with computers from a point of sale will not only result in order filling, data recording, and inventory control, but could also extend further down the line into bank credits and debits. Credit cards could become inputs to computers through data communications equipment. Commercial banks will have interconnecting systems which will lead to up-to-the-minute information on bank and customer balances, eliminating a great deal of the float in the banking system. Total management information systems will be possible by communications links between industrial control computers and data processing computers, transforming the industrial complex into one continuous loop of synchronized data flow.

Electronic computers will be a great impetus to technological development, as it broadens man's capabilities and intellect. The day of trial-by-error will soon be history as the analytical approach provided by simulation techniques will channel efforts to decisions providing the greatest payoff and return.

Just as the electronic computer has already emerged as a new product family of this technology, other entirely new families of machines will branch out from the onrushing mainstream of information technology.

Networks of information retrieval machines - vast data stores of information automatically searched and printed out or displayed on TV screens (documents, for example, related to the indicated area of interest) - will change the role of today's library as well as the mode of research.

Teaching machines and programmed learning are already altering the most fundamental concepts of industrial training as well as the curricula of universities. Machine systems that pace the individual student, continuously analyzing his learning difficulties and mistakes and introducing remedial instruction as needed, all the while allowing direct personal participation of each individual student prohibited by classroom instruction, are today even being hailed by educators as revolutionary in impact. This development is still in its infancy.

Language translation by machine that can scan a page, translate from one language to another, abstract the translation and then store both the abstract and the full article will materially change human communication. Based on a universal machine language of concepts and ideas, rather than direct, literal interpretation, these systems are now in the development stage.

Medical research, today hampered by insufficient and crudely kept statistics, will surge ahead as measurements of many variables - pulse rate, temperature, blood pressure, respiration, and others - are in a form that can be manipulated for research studies as well as used to insure that a physician has a full medical history to aid in diagnosis and therapy.

Traffic control of both air and ground vehicles has been necessary for some time if we are to keep human lives from being subject to the danger of violent death or to hours of waiting in order to travel a short distance at supersonic speed. Information technology is today making such systems possible. Air traffic control at last is being considered for one integrated international system in Europe, controlling all scheduled flights.

Long-range weather forecasting requires the continuous collection and processing of enormous quantities of data. Earth circling systems of satellites, communication nets, and weather machines will be necessary to assemble and evaluate weather patterns on an international basis.

The preceeding applications fall in the category of computer accessible, random access information storage, and retrieval (as opposed to digital file storage), a relative newcomer to the ADP field. During the next few years, rapid advances will occur permitting computer directed composition of graphic presentations from a combination of stored images with stored digital information. Such applications will include the production of blueprints, charts, graphs, figures, etc., and will permit the presentation of material including a combination of alpha narrative, numerical, and graphic information.

More recently there has been emerging a variety of new - so-called second generation - applications of data transmission facilities. These are of potentially greater significance to the ADP field in that they are encouraging new industries to investigate and employ advanced information processing.

One of the most interesting trends emerging in the use of data communications at the present time is in general purchasing operations. By installing data transmission facilities on customer premises, various types of supply firms are now offering fully automated purchasing services by enabling members of the system to transmit orders in punched card form by telephone, eliminating traditional paperwork involved in these procedures.

ADP has created new solutions to problems in many areas of today's society, but few as interesting and imaginative as ADP by subscription. Calling upon the talents of real-time systems, and ever-improving techniques of information retrieval, computerized information centers with subscription services are becoming more important. Some time ago it was predicted that sooner or later cash will be replaced, not by credit cards, but by data processing systems. Instead of a paycheck, an employee is "paid" by a credit to his bank account. As the employee makes purchases, his account is updated, and no cash is exchanged. Though this prediction is unrealized, subscription services are an approach to this type of ADP utilization.

"Data processing firms have a business potential of some 5,400 commercial banks out of the 14,000 in this country. These are banks with over $75 billion in total deposits. The banks which have installed computers have found that they not only have better reports and tighter audit and control procedures, but are now able to offer new customer services and improve their competitive position. The major breakthrough in the banking industry with EDP did not come until 1959, when the final specifications for printing of checks coated with Magnetic Ink Character Recognition (MICR) numerals were approved by the American Banking Association. An estimated 68.3 percent of all checks cleared through Federal Reserve Banks now contain magnetic ink symbols, compared to 36.1 percent a year ago. The volume of checks processed in 1951 was 2.1 billion, but is expected to reach 22 billion in 1970, and 25 billion in 1975. By this time, most of these checks will be coated with magnetic symbols, and will be processed by computers.

"EDP will have its greatest impact on the demand deposit sector of bank employment. About 20 percent of all bank workers doing work related to demand deposit bookkeeping will be seriously affected by the advent of automation. One major bank indicated that computers have led to an 80 percent decline in the number of bookkeepers in demand deposit activity over a four-year period, despite a 10 perce. t rise in demand deposit accounts.

"One of the newest developments in the banking industry is the use of on-line computers. On-line, or real-time systems process transactions individually as they arrive at processor inputs, and usually return a result to the point of origin immediately following processing. In other words, this will make every bank office a main office for every customer, regardless of its location."[5]

We can imagine in the not-too-far future that orders for company B's product can be transmitted from company A to company B via a computer hookup. The order reaches company B, it passes through the credit section of a computer; it receives an O.K.; it then goes into the program of production already pictured selecting the right specification and activating the proper processes. In the meantime, billing and shipment data go into the memory of company B's communication system. Upon completion and shipping of the problem, the computer of company B notifies the computer of company A. Both computers store this information in their memories. When settlement time arrives the computers of both companies notify the computer of a bank or of several banks and the proper debits and credits are made electronically.

A universal consumer credit card system would work in similar way. Instantaneous credit checking in a computer memory would occur and then an electronic transfer from the purchaser's account to the seller's account.

The housewife will also be able to pay bills at any time of day or night without writing checks, addressing envelopes, or licking stamps. She calls her bank's computer, uses her card to tell it her personal checking account number, and the accounts of her payments. The computer debits her account and credits each store's. If she overdraws, the computer can warn her and (depending upon its own internal instructions from the bank's manager, who now presumably can be away fishing) extend credit to her account.

Some of the new uses predicted here may sound visionary, but actually there are some very compelling reasons why new devices and techniques for their use must be created. As our society becomes more and more dependent on paperwork for communications, the population growth in a few years would produce an overwhelming mass of paper with which we could not cope. In order to cope with the sheer physical difficulty of handling the increased paperwork, new techniques must constantly be developed and put to use.

Section III. ADP ORGANIZATIONAL EFFECT

1. Workers

Any office worker, with several years remaining prior to retirement, having no basic appreciation for ADP will most likely find he is not fully equipped to complete his active work life. ADP to many workers involves a complex set of machines, controlled by a peculiar language, and understood only by a group of exceptionally talented people. In the past, a certain air of mystery has surrounded ADP operations, sometimes fostered for the purpose of glamorizing a fledgling industry. Contrary to such misconceptions, most computer displaced workers can, if willing, be satisfactorily retrained. After an initial acquaintance with ADP, the worker will find that it is not nearly so complex as it seems, but that with diligent and properly directed effort in the form of training he can perform some useful part of the changed technology.

"It is estimated that 35,000 workers are displaced by automation each week.[1] The raging argument over whether technology simultaneously creates even more jobs than it destroys is irrelevant to the fact that nearly every new job demands more human skills than each old job; the net result is always a need for more job training. Studies have also revealed that 30 percent of high-school drop-outs permanently join the 2 million unemployables and the 35,000-per-week displaced workers. Obviously, this enormous and growing pool of people needing education and re-education can only be drained through a massive retraining program implemented with mass-education technology. There is already strong indication that the Government plans to 'fight automation with automation.' President Johnson, in proposing a doubling of the total national expenditures on education from 1964 to 1965, specifically proposed first-year spending of $45 million to establish 'regional educational laboratories ... to train teachers and to develop new teaching systems.'[2] It is in these experimental training centers that the first steps toward instructional automation may be taken."[8]

The Federal Government has managed to cope with the problem of worker displacement due to automation, within its own ranks, better than some private businesses because of the large number of jobs regularly available in which to place displaced workers.

"There has been only a small overall displacement impact during the past three years of high-volume computer installations. In ten agencies reporting, there have been only 1,628 actions involving reassignments, declinations of reassignment offers, and separations caused by position eliminations. Only 2 percent of the actions were separations by reduction in force. The extensive efforts of Federal agencies to minimize the adverse effects of automation are apparent here.

"Beneficial factors facilitating the reassignment of displaced employees have been the growth in agency programs, the magnitude of Government employment, the new positions created by automation itself, and the leadtime of two or more years between the initiation of plans to convert and actual operation. Normal employment attrition is expected to continue to contribute to reducing the number of employees requiring reassignment."[4]

Among the implications of technological change for management is the fact that many of the new jobs created by automation will disappear within the decade. Certain types of computer programmers are chief among these jobs. Advanced developments in the organization of computer systems as well as in the effectiveness of computer software will gradually take over a good deal of the type of programming work that has been most common in the early years during which computers have been applied to business. For example, routine "coding" and elementary programming will be handled primarily by the advanced machine systems themselves.

"Emphasis was on the latest developments in source-data acquisition, high-speed data transmission, sans-human-intervention input into computers, and prompt feedback of account-status information, reports, and analyses - all designed to curtail in drastic measure the time between the customer's original order and the completed transaction, and to reduce to a minimum the utilization of human beings in the process. ('Each one of our optical scanners,' one exhibitor pointed out, 'will replace at least fourteen keypunch operators, to say nothing of advantages in smoother operations and practical elimination of human errors.')"[1]

Developments in optical character reading devices which will introduce data directly into the computer system will, in 5 to 8 years, largely replace keypunching for large volume applications. Beyond that, new techniques to be applied in 1969-1970 will have significant employment impact on professional and semi-professional activities not previously touched by automation. These include many functions at the middle management level as well as in the fields of drafting and design. Also, clerical employees, engaged in verification of keypunched data, in minor checking and calculation, and in typing of routine and repetitive documents will find their tasks undertaken by automatic means.

"Company after company can cite huge clerical savings through the use of data processing machines. McDonnell Aircraft, in completely automating its purchasing cycle, estimates it will save $100,000 to $200,000 annually, mostly accounted for by clerical savings, with a machine renting for $6,400 a month. Sylvania Electric estimates that it will save approximately $400,000 to $500,000 annually in such areas as clerical and inventory reductions through the use of machines renting for an estimated $325,000 a year. Nation-wide Insurance has produced savings of about $200,000 a year in the area of Renewal Billings, with a machine which rents for an average of $9,000 a month. Most of this is the result of clerical reductions."[5]

On the middle management side, new methods of systems design that utilize the concept of a corporate data bank, which can, on short notice, respond to questions by top management directly, will impact many middle management activities that are concerned with seeking data, analyzing it, and preparing it for presentation to higher management. Other management functions will increase as a result of a significant shortening of the time lag between the occurrence and the reporting of an undesirable situation or one in need of correction. This will mean more active, "real-time" participation in corporate activities by middle management. The time period 1968 to 1970 will see the large scale application of both the data mechanization and the data bank concepts.

Similar impacts in the field of drafting and design are dependent on cost reductions and improved capability in the area of direct data display. Some of these displays are already available and in use in military installations and some commercial companies. However, by 1968, it is anticipated that designers will be in a position to make modifications and erasures as they see fit, work with a computer in the necessary computations and scaling requirements, and then "freeze" the satisfactory design by photographing the result and reproducing it in as many copies as necessary.

Preliminary systems to accomplish the less complex elements of this activity will be applied in the 1967 to 1968 period, with the more sophisticated elements becoming economically feasible after 1970. Estimates show that this kind of application can reduce a company's drafting requirements by 80 percent in terms of man-hours.

"A professional, and one specializing in the 'new' technology at that, has difficulty visualizing the vast demand for mass education now being generated by technology. As Dr. Emmanuel G. Mesthene, Director of Harvard's automation studies, puts it, 'In the past, we've thought of ... careers that lasted a lifetime. But more and more people will have two, three, or even more careers in a lifetime because technology shifts the pace of society so fast.'

"If in the near future, one of us - perhaps you - should find his current career dropping out from under him, we can hope that a system will have been perfected for teaching old dogs new tricks. O. K. Moore, Rutgers sociologist, has already made a start with his 'talking typewriter;' and he assures us that 'within ten years there will be very complete systems of automated instruction.'"[8]

The answer obviously lies in training and retraining, in some instances labor and management have joined in research and training programs to assist the worker in transition from one job to another. However, there remains some fear among the labor unions that automation will not replace jobs as rapidly as they are eliminated. The views of labor concerning the entire area of automation can well be applied to the ADP area. Table I[6] is a summary of those views with labor proposed solutions.

Table I. Automation: How Labor Sees the Issues and the Action to be Taken

Major Issues Industrial	Action to be Taken By Industry
Decreasing job opportunities in manufacturing, mining, and transportation industries.	Through collective bargaining establish provisions for:
Workers are being "dislocated;" they need more job security.	Shorter work week
Change in wage structure and job evaluation systems	Stronger seniority rights
Labor not sharing in the gains of productivity from automation	Severance payments and other supplementary benefits
Industry's labor needs are changing fast; workers must be retrained.	New systems of compensation, eliminating incentive-type wage payment plans
	Higher wages
	Earlier retirement
	Retraining programs
	Special funds to cope with automation problems.

Table I. (Concluded)

Major Issues National	Action to be Taken By Government
The slow rate of economic growth: The GNP should be growing at a 5 percent annual rate as opposed to the recent 2½ percent growth trend.	Stimulate economic growth through increased Federal spending, foster "job-creating, job-inducing programs."
	Promote a Federal training and retraining program.
Rate of increase in real earnings per worker is too low, not as high as early postwar growth rate.	Government legislation inducing lower work week levels.
Increased number of economically distressed communities.	Greater aid to economically distressed communities.
High sustaining unemployment levels, the possibility of automation leading to "wholesale unemployment and a depression."	State governments should increase unemployment benefit.
	Change Social Security regulations to provide retirement benefits at earlier age.

The ADP impact on workers has been discussed in general terms in the preceding paragraphs. This part deals directly with the workers other than those directly associated with ADP such as systems analysts, programmers, and machine operators. The following impact analysis was compiled from a study of 20 private industry offices utilizing large electronic digital computers. Although the study covers only a 1-year period following the installation of the computers, it should be safe to assume that the trend will continue at the same or possibly a greater rate as equipment becomes more sophisticated.

"Extent of Displacement and Re-assignment. A year following the introduction of the computer, about one-third of the 2,800 employees in units whose work was placed on the computer had been re-assigned to other positions, either within the same unit or elsewhere in the office. (See Table II[9].) A majority remained in the same position. Close to one-sixth had quit, retired, died, or had taken leave of absence. Nine persons had been laid off. Employment in the affected group was about 25 percent less at the end of the year.

Table II. Job Status of Employees of the Affected Units 1 Year After Introduction of Electronic Data Processing, Selected Age Groups[1]

Type of Job Change	All Ages		Under 45 Years		45 Years and Over	
	Number	Percent	Number	Percent	Number	Percent
All Employees	2,808[2]	100.0	2,164	100.0	644	100.0
No Change in Position	1,498	53.3	1,059	49.0	439	68.2
Position Changed	883	31.4	724	33.5	159	24.7
Reassigned within Same Work Unit	552	19.7	460	21.3	92	14.3
Transferred	331	11.8	264	12.2	67	10.4
To Computer Unit	52	1.9	46	2.1	6	0.9
To Other Units	279	9.9	218	10.1	61	9.5
Quits, Layoffs, and Other Separations	427	15.2	381	17.6	46	7.1
Quits	328	11.7	322	14.9	6	0.9
Retirement and Deaths	42	1.5	3	0.1	39	6.1
Leaves of Absence	35	1.2	34	1.6	1	([3])
Discharges	13	0.5	13	0.6		
Layoffs	9	0.3	9	0.4		

[1] Data relate to employees in affected units of 18 offices, 6 months prior to introduction.
[2] Total excludes 7 employees for whom data were insufficient.
[3] Less than 6.05 percent.

NOTE: Because of rounding, sums of individual items may not equal totals.

"A little over 80 percent of the employees affected by the change were in routine jobs involving posting, checking and maintaining records; filing; computing; or tabulating, keypunch, and related machine operations. (See Table III.[9]) The rest were mainly in administrative, supervisory and accounting work. Only a little over 4 percent were engaged in correspondence, stenographic, and secretarial jobs, i. e. the less routine clerical jobs.

"Most of the employees still employed in the offices one year after the installation continued to do the same type of work. About 16 percent of this group were shifted to a different type of routine work, e. g., from computing to posting and checking. A little under 2 percent, a total of 52 persons, were transferred from the affected group to electronic data-processing jobs. Most of these had been doing administrative, accounting or tabulating-machine work; only a few, chiefly for equipment operation, came from routine clerical work.

"Close to one-third of the employees in the affected group had been promoted to a higher grade. A negligible number had been downgraded. Most of the upgrading involved employees under age 45 and to some extent reflected promotions which would have taken place regardless of the advent of the new equipment.

"Effect on Growth of Office Employment. The groups whose work was placed on the computer represented, on the average, only about 5 percent of total office employment. The proportion varied, depending on the nature of the application and the degree of mechanization.

"The immediate overall effect of electronic data processing suggests some retardation in the growth of office employment, particularly routine part-time jobs, for which women are hired. Over the four years from December 1953 to December 1957, total office employment at 17 offices for which data were available increased on the average by 7 percent. This increase, however, was less than the 15 percent rise reported for clerical and kindred workers in the nation as a whole. In six of the 17 offices, the increase was greater than 15 percent; in seven less, and in four there was a decrease primarily because of business conditions.

"Changes in Grade Structure. The introduction of electronic data processing raised the average grade or skill of office occupations, but only to a slight extent. With the elimination of low-paid jobs that were not filled as they became vacant during the transition, the higher paid group became a larger proportion of the total in the affected group. The classification of the new electronic data-processing positions at

Table III. Percentage Distribution of Employees in Affected Units, by Occupational Classification 1 Year After Computer Installation

Occupational Classification	Employment 6 Months Prior to Computer Installation		Occupational Classification												
	Number	Percent	All Groups	1	2	3	4	5	6	7	8	9	10	Electronic Data Processing	Separated
All Groups	2,772[1]	100.0	100.0	1.6	6.2	6.0	22.3	15.2	0.1	1.3	14.1	15.1	1.4	1.8	15.0
1. Administrative	41	1.5	100.0	82.9	--	4.9	--	--	--	--	--	--	--	7.3	4.9
2. Supervisory	176	6.3	100.0	3.4	80.7	2.8	2.3	0.6	--	--	--	2.3	--	3.4	4.5
3. Accounting and Professional	157	5.7	100.0	1.3	3.2	81.5	--	--	--	--	--	--	--	8.3	5.7
4. Posting, Checking, and Maintaining Records	719	25.9	100.0	--	0.4	1.1	68.6	4.0	0.4	0.4	3.5	1.7	1.5	0.4	17.9
5. Computing and Statistical	492	17.7	100.0	--	1.4	2.2	7.1	73.4	--	--	1.8	0.4	0.6	0.4	12.6
6. Correspondence Work	3[2]	0.1	100.0	--	--	--	--	--	--	--	--	--	--	--	--
7. Stenographic and Secretarial	34	1.2	100.0	--	--	--	2.9	--	--	85.3	2.9	--	--	--	8.8
8. Keyboard or Keypunch Machine Operations	447	16.1	100.0	--	0.2	0.4	4.5	1.8	--	1.1	72.9	2.2	--	0.7	16.1
9. Tabulating and Related Machine Operations	618	22.3	100.0	0.2	2.4	1.3	5.5	3.4	--	--	3.6	62.0	1.0	3.1	17.6
10. Sorting, Routing, Classifying, and Filing	85	3.1	100.0	--	--	--	34.1	1.2	--	--	9.4	8.2	23.5	--	23.5

[1] Excludes 43 employees for whom data were insufficient.
[2] Insufficient data to warrant presentation of percentage distribution.

NOTE: Because of rounding, sums of individual items may not equal 100.

the top of the office pay structure also tended to upgrade the pattern. Since these groups at the bottom and the top of the pay structure constituted but a small proportion of total office employment, the net effect on the structure of an entire office was small.

"New Jobs. A small number of new positions were created to operate, programme, and manage electronic data-processing activities. The average number of persons employed in these units at the time of the study was 29. Close to seven out of ten persons in electronic data-processing work were in programming and planning positions; about 25 percent were engaged in operating the equipment; and 8 percent were in administrative and supervisory occupations."[9]

The impact on worker requirements in terms of workers that change from non-ADP oriented to ADP oriented jobs should be kept in mind. Table IV[10] shows the previous work experience of personnel now employed in ADP jobs with 20 major U. S. corporations. These figures indicate which type workers appear to be best suited for ADP work. Managers should consider this job shift in order to ensure an uninterrupted supply of all type workers.

Table IV. Previous Work Experience

Previous Job Classification	Total (%)	Administrative & Supervisory (%)	Planning & Programming (%)	Operation (%)
Accounting and Professional	35.5	44.9	43.5	9.6
Administrative and Supervisory	13.3	40.6	11.9	9.8
Tabulating and Keypunch	13.1	2.9	4	40.6
Posting, Checking, and Filing	10.7	2.9	9.3	17.5
Statistical	5.4		6.0	4.7
Correspondence and Secretarial	2.0		1.7	3.7
Nonclerical	1.2	1.4	1.1	1.4
New Employees	18.9	7.2	22.1	12.7
Total	100.0	100.0	100.0	100.0
Numeric Distribution	915.0	69	637.0	209.0

The projected use of computers as discussed in the introduction indicates a rapidly growing need for ADP oriented personnel. This part deals with workers directly associated with ADP equipment.

The impact of the need for increased ADP oriented personnel is reflected in Tables V, VI, and VII.[11] ADP oriented personnel, analysts, programmers, and operators are defined as follows.

Table V. Personnel Requirements - Estimated 1964

	Category of System				
	Manual Input	Small Scale	Medium Scale	Large Scale	Total
Analysts	1,729	18,264	7,860	6,696	34,549
Programmers	5,187	45,660	15,720	11,160	77,727
Operators	5,187	22,830	9,825	5,952	43,794
Total	12,103	86,754	33,405	23,808	156,070

Table VI. Personnel Requirements - 1970
Projected, Without Technological Change

	Category of System				
	Manual Input	Small Scale	Medium Scale	Large Scale	Total
Analysts	5,250	54,400	24,000	20,700	104,350
Programmers	15,750	136,000	48,000	34,500	234,250
Operators	15,750	68,000	30,000	18,400	132,150
Total	36,750	258,400	102,000	73,600	470,750

Table VII. Personnel Requirements - 1970
Projected, Including Technological Change

	Category of System				
	Manual Input	Small Scale	Medium Scale	Large Scale	Total
Analysts	4,200	48,960	21,000	18,400	92,560
Programmers	10,500	81,600	30,000	23,000	145,100
Operators	10,500	40,800	18,000	11,500	80,800
Total	55,200	171,360	69,000	52,900	318,460

1) "Analysts includes systems analysts, problem analysts, mathematical analysts, and their supervisors, with responsibility for problem analysis to the point of job specification.

2) "Programmers includes logical analysts, coders, testing and documentation personnel, and their supervisors, with responsibility for translating the specification into a working system.

3) "Operations include console operators, tape handlers, satellite computer operators, and their supervisors, but not EAM operators, librarians, or input-output personnel." [11]

The study from which Tables V, VI, and VII[11] were derived considered many factors which will undoubtedly influence ADP personnel requirements in the future.

"To begin with existing requirements (Table V[11]), the need for personnel in the computer field today can be expressed on the basis of known quantitative data concerning the industry. The April 1964 Computers and Automation census provides the basis for the estimates and extrapolations which follow. This census gives data concerning presently installed systems and systems 'on order.' The latter category is interpreted to mean systems which will be installed within 2 years, or, for purposes of this article, in the near future.

"The method of determining present personnel requirements is based on classifying computer installations by size of computer, and approximating to personnel requirements for each size of computer.

"A variety of estimates are available concerning the market for computers in the 1970's. A consensus of the most reliable of these indicates that by 1970 the number of systems installed will approximate 52,000, with another 10,000 on order. It is not unreasonable to assume that the distribution of these systems will be comparable to the distribution of today's systems within the four classifications. For example, since 12 percent of today's systems fall into the medium-scale category, it is assumed that 12 percent of 1970's systems will fall into that category.

"It is farfetched to imagine that in the 6 years remaining before 1970, the number of people in the computer field can be tripled (Table VI).

"In the first place, the educational facilities for this kind of an undertaking are not available, nor is the economic capability for absorbing a training program of this magnitude. If, in fact, staffing patterns and procedures normal for today were required for the computer systems of 1970, it is highly unlikely that the capability would exist to use the 52,000 systems properly.

"A number of technological changes may be expected that will reduce the number of persons required in each of the projected installations. To appreciate these changes, and to arrive at a reasonable assessment of their impact, they are listed and discussed below.

1) "Automatic Programming. This often misapplied term is best defined to mean the use of more advanced languages and compiler systems. This will reduce the tediousness and routine which programmers must now go through. Also, automatic programming will increase the efficacy of documentation and of testing, and perhaps it will eliminate the coding function. Probably automatic programming will not eliminate logical analysis; it certainly cannot eliminate all aspects of testing; and most likely it cannot eliminate the major factors involved in good documentation. It may be reasonably assumed that the impact of automatic programming, as defined above, will reduce total programming requirements by approximately 25 percent.

2) "Libraries. The use of libraries constructed by manufacturers or by user groups will certainly become increasingly popular. The availability of libraries will have a significant impact on the need for systems analysts and on the need for programmers. However, no amount of library work can eliminate all of the unique problems which each organization faces. Therefore, considering the impact of automatic programming on programming requirements, it may be estimated that the reduction in personnel brought about by much greater use of libraries, will be approximately 10 percent in systems analysts.

3) "Monitor Systems. Monitor and operating systems have tremendous merit in the proper management of operating installations. It is expected that by 1970, over 80 percent of all computer installations will be completely operated under monitor system or operating system control. Consequently, the operating personnel requirements will be reduced, although of course there will remain an irreducible minimum. Although it will be less in specific cases, the over-all reduction can be estimated to be approximately 40 percent.

4) "Organizational Centralization, and Decentralization of Input/Output Facilities. The organizational structure of the data processing function in corporations is now being changed to achieve over-all economics and increased efficiency. However, the total economies achieved by such measures as (1) centralizing corporate administration

programming and (2) decentralizing input preparation and output operation, are somewhat offset by the need for satellite operations and the need to have standby programming capability within these satellite operations. It is therefore estimated that organizational changes of this type will reduce the need for programming by about 5 percent, but will increase the need for operators by about 5 percent.

5) "Software Packages. The market for software packages to be purchased is likely to continually increase. Unquestionably a number of software organizations will develop additional proprietary systems which they will make available for sale. As in the case of libraries and shared-user programs, there will be some impact on programming and systems analysis requirements. Since purchase prices for these software packages will probably be heavy, the total reduction of installation facilities is estimated to be 5 percent in systems analysis.

6) "Software Development. All of the above technological improvements will require implementation in and of themselves. This means that the creation of these improvements is going to require additional manpower. For example, if COBOL and FORTRAN must be implemented for each and every system available today, a safe estimate is that perhaps 5,000 man-years of programming effort will have to be invested in that implementation. Therefore, there is an offsetting cost in the technological changes which will be available by 1970. Briefly, this cost is the cost of creation of software, and it can be estimated to be approximately 10 percent in programming and 5 percent in systems analysis requirements.

"Totaling these estimates, the following is the net effect:

1) A net reduction in systems analysis requirements of approximately 10 percent

2) A net reduction in programming requirements of 35 percent

3) A net reduction in operations requirements of 35 percent.

"Based on this expected reduction, approximately 92,000 systems analysts will still be required. The number of programmers has been reduced by approximately 80,000, to 145,000, and the number of operators has been sharply reduced to 80,000. But the grand total is still 318,000 people (Table VII)." [11]

The recent increase in appropriations by the Federal Government for education, the willingness of Labor Unions to contribute to automation displaced worker retraining and the efforts on the part of Business Management to influence school curricula all indicate the problem, though large, is directed toward solution. However, the individual and the manager must assume responsibility for the transition.

We can see only increased benefits to mankind resulting from the growth of ADP. It is hoped that the worker who is directly effected will share this view.

"Let us look, for example, at automation as perceived from three viewpoints: that of the individual, the manager, and public policy.

"The individual perceives automation as a job threat or, if he be a mathematician, engineer, or otherwise situated to benefit, he perceives it as a challenge and an opportunity.

"Yet automation is going to force the individual - and all of mankind - to reconsider his very conception of himself. As Professor Herbert A. Simon of Carnegie Institute of Technology states: 'The definition of man's uniqueness has always formed the kernel of his cosmological and ethical systems. With Copernicus and Galileo, he ceased to be the species located at the center of the universe, attended by sun and stars. With Darwin, he ceased to be the species created and specially endowed by God with soul and reason. With Freud, he ceased to be the species whose behavior was - potentially - governable by rational mind. As we begin to produce mechanisms that think and learn, he has ceased to be the species uniquely capable of complex, intelligent manipulation of his environment.

"In at least one respect, the changes automation will bring to labor are all to the good. Norbert Wiener has said that the 'human machine' is too complicated for such tasks as pasting labels on tin cans, or sorting and packing spears of asparagus, or tightening one or two bolts on a car on an assembly line; and that 'it is degradation to a human being to chain him to an oar and use him as a source of power; but it is an almost equal degradation to assign him a purely repetitive task in a factory which demands less than a millionth of his brain capacity.

"These are the very jobs that machines will take over in an automated factory or office. Considerably fewer workers will be needed for routine, monotonous jobs because machines will be doing that work. The jobs that will be reserved for people are those requiring judgment and those that a machine cannot readily be built to do - in other words, the more interesting ones."[6]

2. Managers

The impact of ADP on business has served to validate the premise that managers must be dynamic in their guidance of an organization. The ability to detect and apply useful new management tools and instill within employees the desire for improvement are more essential to good management than ever before.

"In 1950 when computers were new, it seemed to many that they were only useful for scientific purposes. One proj[illegible] estimated the need for about a dozen in the United States. That [illegible] 10 years ago. Today we have over 15,000 computers at work. The [illegible]jections of my own firm are that after 1965, there will be about [illegible]0,000 computers installed in the United States alone.

"We are today using this technology in only the most elementary manner. New techniques utilizing computer capabilities are just beginning to appear on the business scene. Operations research (the building of mathematical models to solve business problems), simulation (using the computer to supply 'what would happen if' answers to decision alternatives), and gaming theory (to plan strategically in competitive markets) are but a few."[16]

"Most company managements are out-moded and no longer adequate to direct the complex structures of their companies," Dr. R. L. Martino, head of Olin Mathieson Chemical Corporation's Advanced Systems Department, told attendees at the Systems Engineering Exposition and Conference held in New York on June 8-11. "A new brand of managers is urgently needed," he said, pointing out that we are only at the beginning of harnessing modern computers and the systems engineering approach to control the business environment. "The corporation executive of the 1970's will be seated behind a computer, not a desk," according to Martino - and "the board room of the corporation of tomorrow will look like the war room of an army general with computers displaying all the pertinent information upon which the staff must make its decisions."[12]

Equipment is available on the market today which is capable of meeting almost every requirement for gathering, recording, processing, communicating, and reporting business data. Processing speeds are virtually supersonic, storage capacity is unlimited, input and output capabilities exceed the ability of man to create the source data or to digest the results. In short, the limitations on application of electronic equipment are governed only by the ability of the programmer or systems engineer to utilize them, and management to afford them. Systems can be designed to meet every challenge. There is little doubt that future adaptions of electronic data processing techniques to new problems can and will be successful.

The full potential of the computer has not been realized yet, and the greatest potential payoff appears to be in sophisticated areas which have been out of man's reach to date, such as totally integrated management information systems.

Obviously much remains to be done before the full value of the computer is realized. Although a degree of computer familiarization is desirable for managers, it is not essential that they become specialists. Managers can sit at the computer or console and observe the conduct of his operations without a detailed knowledge of computer programming or operations techniques. The important consideration is that adequately trained specialists provide full advantageous use of the computer for the organization.

In the electronic age specialization will be an embarrassment to anyone with managerial aspirations. The instantaneous availability of quantities of correct information on all phases of business, the analysis of situations by computers and knowledge of the consequences of one course of action compared to other possible course will make the specialist obsolete as a manager. This will demand an executive of broad knowledge and appreciation of the total picture in his company and industry. This executive will make decisions in the context of totality, not as a specialist.

Direct access to all available information on the business that can be presented in a variety of summarized or comparative forms will increase the premium on scientific management. The use of data display and high speed communications will permit a new approach to management action.

In order for the manager to apply totality as a management thesis, an information system which will provide the essential facts must be made operable. An organized discipline of information systems in business must be developed to replace the piecemeal approach that exists now.

The systems function, when it exists at all within a business, is a collection of mixed techniques usually dealing with operations at a very low level - how many carbon copies to make, how to maintain usable cross-reference files, how to handle purchase requisitions, and the like.

Business is a complex information system, but we have yet to organize an effective approach to handling the flow of information within business. Our limitation is not attributable to the computer system, for the capability of machines has far outstripped our knowledge of how to use them to optimum advantage. What we lack is a fundamental understanding of the very business processes with which we have lived for many years. It is a truism that only when we attempt really to understand the functioning of a business system, in order to utilize most effectively our new technology, do we discover how little we know of our business operations and of ourselves. Systems discipline will ultimately come from improved understanding of control concepts and control opportunities. It will spring, too, from a more perceptive appreciation of organization and organizational relationships, of the flow of information and of how it should be used.

In order to achieve an organized discipline of business-information systems fully to utilize automation technology, a new professional classification is called for in business and industry.

The problem of building systems control requires the most thorough consideration and analysis by management. Yet management's very first rule, that authority must be commensurate with responsibility, is disregarded at almost every computer installation. The responsibility for incorporating technological advances, and putting them to work, is almost universally placed at too low a level, usually in a financial department, sometimes in the engineering department. Further, this responsibility tends to be associated with just one functional leg of the business and is not accepted as a company-wide service.

Under the present concept, management control is generally a part of the accounting function. Adequate use of ADP will permit the accounting function to be integrated into the management control system. The demands of the future will require accounting to become a part of the management function serving as an interpretive step between planning and operations on one side and measurement and evaluation on the other.

The role of middle management will change as the function of allocation of resources is performed by computers. Some predict the disappearance of middle management as a line function and the growth of a new staffing function - the analysis and continuing reappraisal of the computer models and of the assumptions on which they are based in order to keep the system sensitive and itself receptive to change.

A new position must emerge within business organizations to fill this vacuum. A differentiation must be made between operating responsibilities - between the manufacturing, marketing, and planning functions. A planning function, charged with responsibility for analyzing a company's business and performing research in business information and information systems, is now beginning to become apparent at suitably high levels within some managements. It is urgent that this new function, this new profession, be recognized and developed rapidly if full use is to be made of information technology.

A broadening of traditional positions must also emerge to cope with the ever increasing complexity of the systems discipline. The accountant-systems analyst, mathematician-ADP programmer, clerk-ADP machine operator, etc., will be essential to perform auditing, review and analysis, and clerical functions required by the total system.

"How does electronic data processing affect the career opportunity of the accountant as a corporate executive? This is really the most important of all considerations.

"To begin with, some accountants are apprehensive, even hostile, assuming adverse effects of computers on their positions, particularly if computer utilization spreads as fast in the future as it has in the past. Some accountants fear that computers will become so sophisticated that they will take over, not only routine work of accountants but also the special decisions, thus making widespread unemployment in the ranks. There is no foundation for this concern. Not one accountant will ever be replaced by another accountant who understands computers. We are considering only the extra knowledge the accountant must gain and the extra duties he must assume. It is not suggested that any of the responsibilities he now has will in any way be lessened.

"Any computer-based recordkeeping system requires two indispensable groups of skills:

1) Group 1

   Procedures analysis
   Programming
   Computer operations

2) Group 2

   Control.

"In many companies, the personnel of the first group usurp the duties of the second, also. In other words, programming staff not only changes the procedures and programs the computer, they also take over the design of internal controls. This happens, not because the programmer is greedy for power or is trying to do the accountant out of his job but by default, because the accountant has not asserted himself as guardian of corporate control.

"One rarely sees trained programmers with a depth of accounting training. A company is following an unsafe course unless the accountant participates in, directs, and approves the inclusion of control steps in all computer programs." [13]

Another adjunct to maximum computer utilization made possible by on-line, real-time capabilities is the direct man-computer relationship for problem solving.

"Bright humans shine in the setting of goals, the generation of hypotheses, the selection of criteria - the problem-solving phases in which one has to lay down the guide lines, choose approaches, follow intuition, exercise judgment or make an evaluation. These aspects are called heuristic, meaning that they lead toward or facilitate invention or discovery (Problem-Solving Machines, December 1964). Both the heuristic and the algorithmic aspects of problem solving are seen throughout science and technology and wherever problems have to be solved or decisions have to be made. They are, indeed, the complimentary aspects of thought.

"In the general run of computer applications today the heuristic aspects of problem solving are almost wholly separated from the algorithmic aspects.

"Because of the forced separation of heuristic from algorithmic aspects, conventional digital computing is limited in application to those problem areas in which such separation can be made.

"Men excel in heuristics and computers excel in executing algorithms. Yet, for about 20 years men have been solving problems with the aid of - but usually without interacting closely with - large digital computers. What has been the nature of that conventional, noninteractive use of computers?

"Having perfected his program to the point of passing the assembler's or compiler's test, the problem solver may apply the program to substantive data. If the problem is complex, as we have been assuming, or if the data are voluminous, that application is likely to result in sorrow. How is the problem solver to know whether or not his program calculated what he wished it to calculate? Perhaps he can tell by inspection whether or not the results are reasonable. Very probably they are not. How is he to tell why not?

"Perhaps he had foresight and ordered the computer to take copious notes at every stage of the calculation. He can take the print-out home and study it over the weekend. Indeed, he may be fortunate enough to find an error on the first one of the print-out's 500 pages, in which case the other 499 may be nonsense. He can repair the one mistake, go back for a re-run on Monday, and spend Tuesday pouring over 500 new pages of protocols recorded for him by the computer.

"Underlying the difficulties of forging a successful intellectual partnership of man and computer are the 'speed-cost mismatch' and the 'language mismatch.'

"It seems to me that the essential facts relevant to memory requirements are listed below:

1) "Computers with small memories are good for some special purpose.

2) "Many problems absolutely require large memories for their solution.

3) "To make computers widely available and effectively useful for solving complex problems, it is necessary to develop advanced problem-oriented languages designed for use by people not skilled in the art of programming, to provide organized systems of prepared programs, and to provide files of generally useful data.

4) "Such facilities will require much memory space.

"The concept of man-computer interaction virtually demands a large multiconsole computer system, a multiconsole system in which the consoles are not just typewriters but truly consoles. The concept requires that the system include abundant software - a great and overgrowing collection of public programs and data - as well as advanced hardware. The concept requires a marked advance in the design and mastery of languages for communication between man and machines - families of languages that include not only languages to facilitate preparation of programs but also languages to facilitate control of computer processes through retrieval and application of programs already prepared, tested, and stored in the computer's memory. And, perhaps most of all, it requires development of groups or communities of sophisticated users, capable not only of using the computer's services but also of contributing to advancement of its services."[14]

The challenge to management posed by technology is a challenge of basic theory as well as of operation. It is here that United States business is having the greatest difficulties in effectively putting the new technology to work. It is possible that our educational system, which is empirically based, needs a more theoretical orientation.

The third basic issue is that of educating future managers in information disciplines.

The newly emerging planning functions call for versatile, skillful, highly trained information specialists and planning executives. The International Business Machines Corporation has initiated a professional systems institute, at graduate school level, which is attempting to piece together an organized discipline for education in information. Industry as a whole has not yet squarely faced the problem. Universities are more keenly aware of their responsibilities to prepare for the radical changes that will occur in professional standards. A number of special courses have been created in computer and information technology at undergraduate and graduate levels. It is essential, however, for the implications of the new technology to be given greater attention in finance, production, marketing, and industrial engineering courses.

The increased complexity and tightened interrelationship of functions within a single organization, together with the ever more complex relationships with other organizations, means that successful - and successful is increasingly coming to mean rapid - adjustment to change is impossible without a high order skill in planning.

"Rear-view management is no longer tolerable in a dynamic, fluid, competitive economy where profits are hairline margins and decisions can involve many millions of dollars. The computer, then, is a time breakthrough. On the other hand, the computer's prime contribution to management will not lie in the area of supplying timely data. Rather, it will be in providing a framework for planning strategy. Computers allow management to do this through a technique known as simulation for model-making.

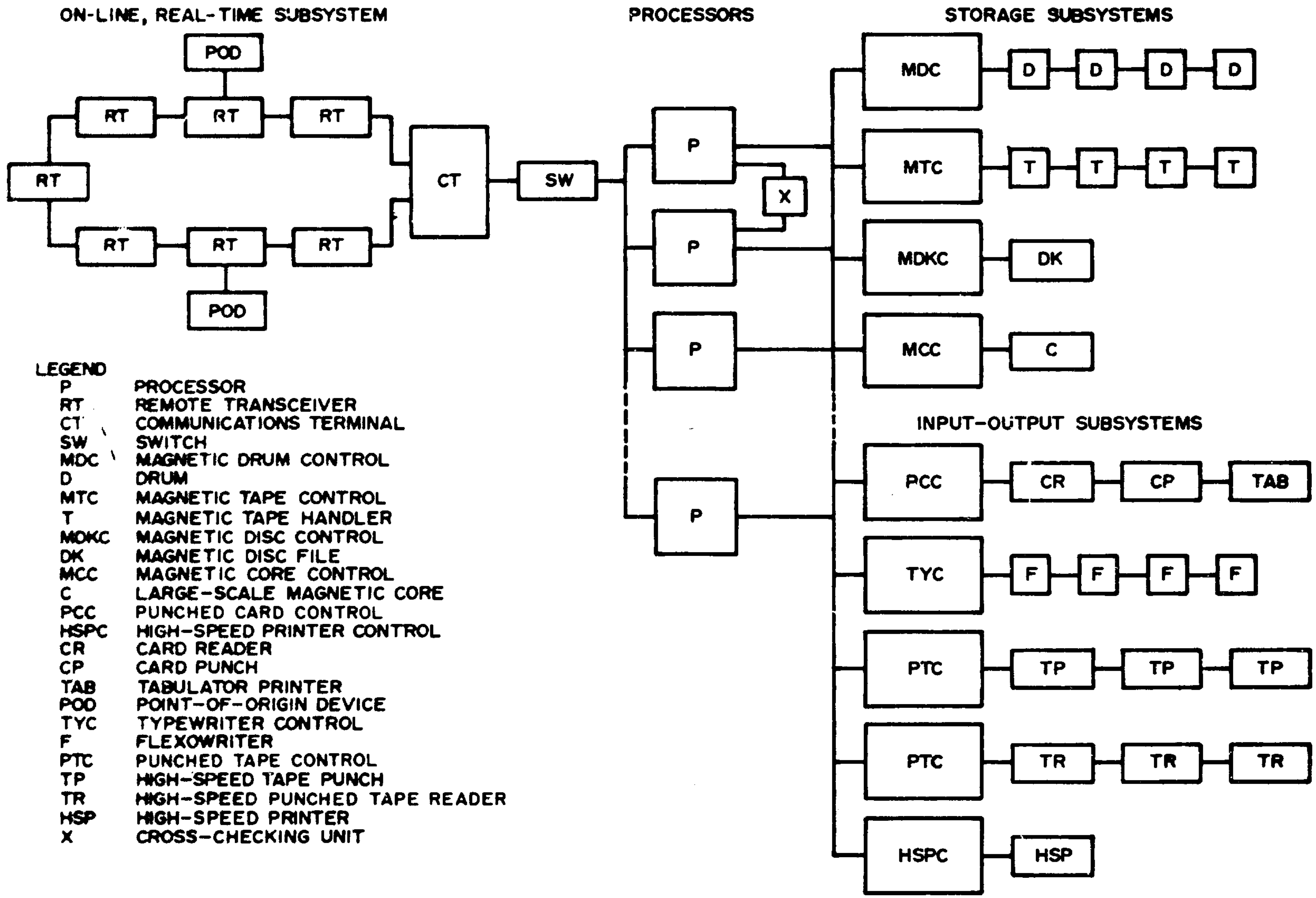
"This technique should not be entirely foreign to accountants as they perform a similar service in the basic function of keeping books.

An accounting model of the business keyed to profit and loss is constructed. A computer model, however, will embrace many factors other than financial. It will simulate mathematically such business variables as manufacturing capacity, price schedules, inventory level, etc. Using the theory of gaming, it is possible to vary the parameter of makeup, for example, to determine in advance, with reasonable accuracy, what effect different management decisions will have on profit and loss." [14]

The development of the total management information system including mathematical models, simulation, the gaming theory and man-computer relationships will require the use of on-line, real-time, third generation equipment selected to fit the particular situation. Figure 7[7] shows a third generation processor system containing all available equipment. It is unlikely that any one application would require all the equipment shown. The point-of-origin devices (POD) and remote transceivers (RT) are capable of both input to and inquiry from the storage subsystems. The POD could be a console or any of the many inquire-display panels. The communications terminal is actually a computer, programmed to review incoming messages and route them to the appropriate processor. The processors perform all computing operations in accordance with the demands of the incoming message. The storage subsystems and input-output subsystems contain all types necessary to provide the required memory or input-output media.

Management must utilize present electronic data processing hardware to monitor current operations. From a technical standpoint, multilocational companies should be able to integrate their various locations by means of a high-speed digital communications system. Data can be fed into a central processor from "satellite" computers or from transmission units located in the individual plants. Such data can then be summarized for top management reports. In other words, it is now technically possible to monitor the exact state of affairs in a complex organization during its actual operation.

Ultimately, it should be possible to use real-time (or up-to-date) operational data to modify present operations. In order for the computer to do more than just monitor present operations, it will be necessary to develop a "model" or simulation of the operation to be controlled. The model then receives inputs of operational data and notes deviations from ideal operation according to the value system built into the model. When a deviation from optimal operation is detected by the simulated system, self-correction routines can be initiated automatically.



LEGEND

P	PROCESSOR
RT	REMOTE TRANSCEIVER
CT	COMMUNICATIONS TERMINAL
SW	SWITCH
MDC	MAGNETIC DRUM CONTROL
D	DRUM
MTC	MAGNETIC TAPE CONTROL
T	MAGNETIC TAPE HANDLER
MDKC	MAGNETIC DISC CONTROL
DK	MAGNETIC DISC FILE
MCC	MAGNETIC CORE CONTROL
C	LARGE-SCALE MAGNETIC CORE
PCC	PUNCHED CARD CONTROL
HSPC	HIGH-SPEED PRINTER CONTROL
CR	CARD READER
CP	CARD PUNCH
TAB	TABULATOR PRINTER
POD	POINT-OF-ORIGIN DEVICE
TYC	TYPEWRITER CONTROL
F	FLEXOWRITER
PTC	PUNCHED TAPE CONTROL
TP	HIGH-SPEED TAPE PUNCH
TR	HIGH-SPEED PUNCHED TAPE READER
HSP	HIGH-SPEED PRINTER
X	CROSS-CHECKING UNIT

Figure 7. Third Generation Processor System

While the hardware available today makes it feasible to devise systems that can monitor present operations, there still is not sufficient knowledge of the complex workings of a business system to superimpose a working model on an operating corporation so that modifications or corrections can be made. Real-time systems have proven practical in such industries as banking and air transportation because in these industries there are a limited number of variables necessary to describe the operational environment. The difficulties in obtaining similar operation information in a multilocational, multiproduct manufacturing company are significantly greater. A real-time communications network has not yet been established for such a company.

Several large manufacturing corporations in the United States are actively attempting to devise corporation information networks that can be used eventually as the basis for a computer controlled centralized data gathering system. However, even if these companies succeed in developing such a complex information network, they will still fall far short of the major task of formulating an operational model of the company from which to achieve the next level of control. This consists of superimposing the model on the information control system in order to achieve some degree of automatic control over operations. Such systems are still in the future as far as the business world is concerned.

Meeting the challenge of maximum utilization of the equipment and systems available to today's managers is vital to the future successful operation of every organization. Figure 8[6] shows a predicted time table for the use of many new ADP applications.

3. Organizational Structure

The tremendous impact of ADP on the total business structure has created doubt in some quarters as to the validity of recognized basic principles of organization.

Today's business organization structure is a legacy of the first industrial revolution in which specialization of labor was followed by mechanization around specialties. We are now in possession of technology which allows us to build information systems transcending the compartmentalized structure of business organization. Much of the difficulty that we have been experiencing in putting these new tools to work in recent years results from the fact that it clashes with our fundamental organization system. This is a problem that is not yet recognized by many of the organizations experiencing it.

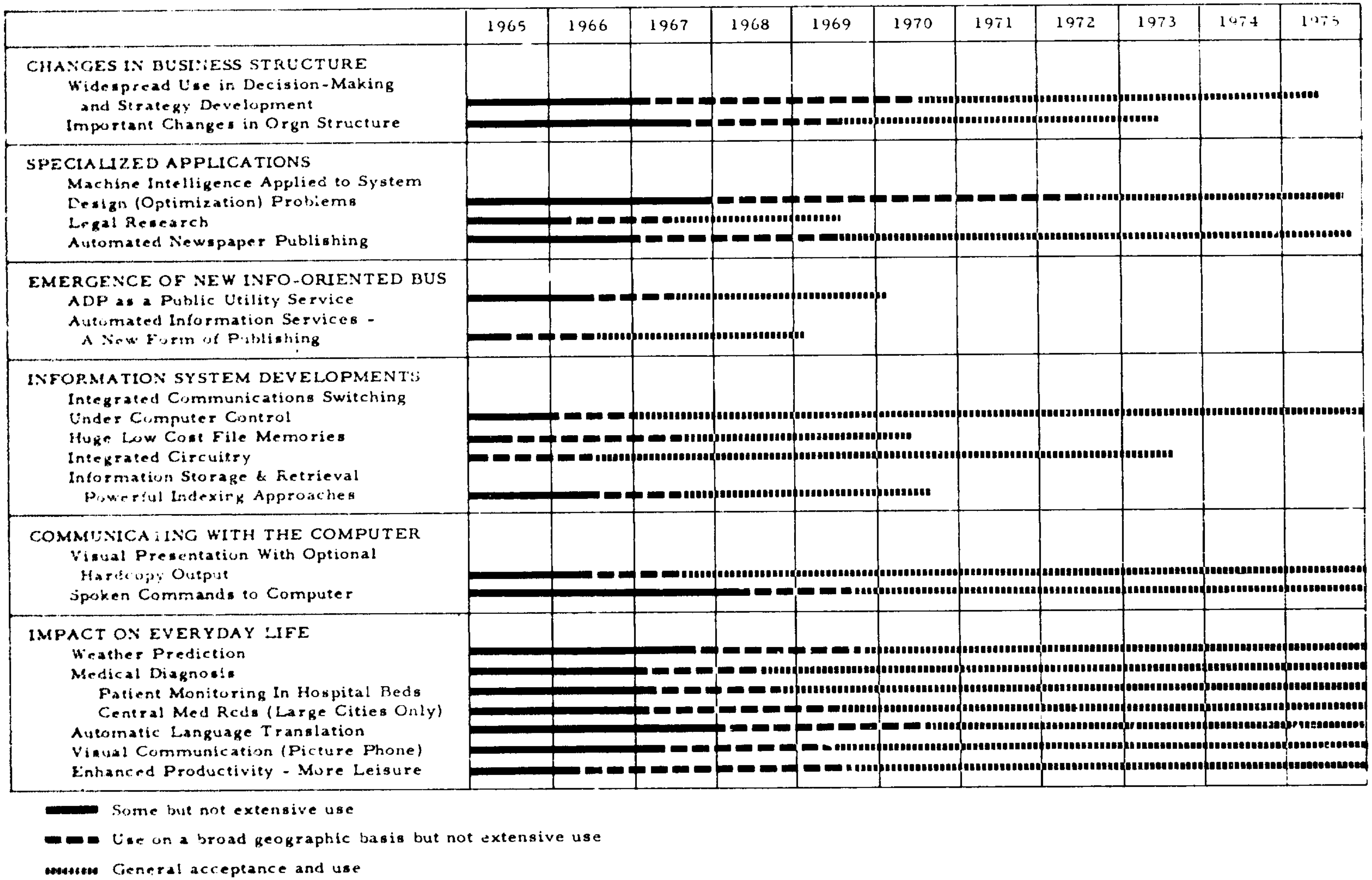


Figure 8. Information Technology Timetable

It is suggested that much of the confusion is caused by violation of the basic organizational principles rather than by their becoming obsolete. Certainly the use of ADP with its operations cutting across organizational lines combined with the lack of managerial understanding on its full use, has contributed to the feeling that something is wrong. As pointed out in the preceeding sections, ADP permits the machine to accomplish internally many steps that were previously the estate of several organizational segments.

It is apparent that the computer, through its stored program, is capable of performing such routine tasks as: granting credit, reordering stock, writing off delinquent accounts, issuing purchase orders, approving vendor invoices, and preparing checks. These are certainly not all of the duties which might be assumed by the computer, but they are sufficiently representative to indicate how the system of authorizations and approvals is now part of the computer's program.

A computer system, by just one pass of the data, can record the sale and the receivable, modify the inventory file, compute the cost of the sale, test to see if the inventory needs to be replenished, type a purchase order if necessary, and prepare an invoice and shipping documents which relate to the original transaction. Since the computer has performed all of these operations without manual intervention, not only has there been no division of duties, no authorizations or approvals, nor any lines of responsibility, but the incredible accuracy of the computer has even eliminated the need for arithmetical verifications.

The foregoing discussion illustrates that traditional methods of implementing internal control need only be adapted in the input-output phases of an EDP system; and separation of duties, authorizations, approvals, manual comparisons, recomputations, and the like, are either unnecessary or should be extremely modified in the processing phase of an EDP system.

"Internal control, in the broad sense, includes...controls which may be characterized as either accounting or administrative.... Accounting controls comprise all methods and procedures that are concerned mainly with, and relate directly to, the safeguarding of assets and the reliability of the financial records .... Administrative controls comprise all methods and procedures that are concerned mainly with operational efficiency and adherence to managerial policies...."[1]

For many years, internal control has been identified with such characteristics as the division of duties, a network of authorization and approvals, arithmetical verifications, and lines of responsibility; however, with the ever-increasing centralization of data processing through the use of large-scale electronic computers, there has been a tendency to consolidate many of these functions.

Rather than question the validity of organizational principles, management must recognize deviations from them caused by the use of ADP, and revamp the structure to provide a sound framework within which the principles will be permitted to function. The success of an organization built around the grouping of like functions or separation of duties is more dependent today than ever on the principle of delegation of authority commensurate with the assignment of responsibility. For example, within the computer facility there should be at least four separate and distinct groups of individuals, the planners (system specialists and programmers), the machine operators, a group responsible for output controls, and a record librarian. In this way, no one group has direct and complete access to the record-keeping system. For example, the planners, who are intimately familiar with the stored program and the entire EDP system, should have no contact with the day-to-day operations. On the other hand the machine operator's knowledge of detailed programs and the historical records should be sufficient enough to enable him to perform his job as an operator effectively; too much knowledge can lead to intentional or unintentional manipulation of data, but too little knowledge might reduce the efficiency of the entire data processing unit. Responsibility for output controls should be identified with the internal audit function.

The presence of a record librarian assures that programs, as well as historical records, will be adequately controlled. By assigning one individual, one who has no relationship whatsoever with any of the other data processing activities, the responsibility for the custody of all file information, only authorized changes can be introduced into computer programs or historical records.

No clear-cut trend was discernible in the literature reviewed pertinent to the organizational placement of ADP systems design and programming personnel and subject matter specialists such as accounting, planning, budgeting, etc., personnel. Some preferred a centralized ADP organization including systems design and programming personnel with subject matter specialists decentralized to operating organizations. Others preferred to decentralize all functions, including ADP machine operations.

Management must understand that company organization may have to undergo major changes before the computer system can reach its full potential. Often, previously independent corporate functions will be merged. In one company, for example, the plant cost-accounting system and the manufacturing control system were integrated into a single plant information system.

The following are some predictions concerning future placement of functions due to the influence of ADP on organization.

From an organizational and operating point of view, management can expect the following impacts and changes between now and 1970, with some of the changes already overdue. Many activities previously kept separate within the organization are merging. These activities include functions originally departmentalized that will be integrated through information processing, such as order processing, billing, accounts payable, inventory management, and production planning and control. Also affected are actual data processing activities that have grown up separately. The systems and procedures, the electronic data processing, the corporate communications, the scientific engineering, and business data processing activities will merge. The tendency toward centralized data processing will gain momentum.

The impact of ADP does not alter the merits of centralization versus decentralization as pertains to the organizational structure of an enterprise. Centralization or decentralization should be applied as dictated by the particular situtation. Centralized ADP does tend to favor centralized organization in the eyes of some managers.

Management has a capacity never possible before either to centralize or decentralize its decision functions. The advances made in communications, among machines as well as people, now allow for direct, cheap, and immediate flow and feedback of information among any geographic points. Whether or not centralization is appropriate will vary with the situation, but the decision need no longer fall automatically to decentralization.

The fact that ADP provides the vehicle for a centralized organization does not in itself justify such an action. To many managers, this newfound ability to have centralized data at their fingertips has caused them to centralize the organization without consideration of all the factors influencing the operation. At first look, it appears that all management decisions can be made at the point of data centralization and perhaps with perfected use of mathematical models, simulation, and the gaming theory, this will be possible. All of this may change the requirements for lower level managers from time to time, but there is little evidence that many enterprises will successfully operate without them. Managers should exercise caution to prevent the confusion of centralized records and record keeping with centralized management.

The future, it now seems quite probable, will see further centralization of clerical work. The work of outlying and smaller units will be absorbed into the over-all system. The extension of data processing into the area of minor decisions will also enlarge the scope of mechanized clerical work. Centralization of data processing, a greater centralization and mechanization of detailed planning, and more direct communication with operating units will be characteristic of the operating scene. Interdepartmental records will be more extensive as the arguments of speed, sophistication, and economy, always claimed by mechanization and centralization, will override arguments in favor of the continuance of separate departmental records. The availability of quick access to centralized information will, in fact, eliminate the last major advantages which departmental records could claim.

On the other hand, one development in computer technology could alter this trend. Relatively inexpensive data processing and communications equipment make it possible to operate decentralized satellite systems under centralized control. Mechanization and integration thus continue but the process of physical centralization need not.

The centralization of records and record keeping will continue at a greater rate than was imagined a few years ago until by 1970 most business will have centralized records.

These projected developments will affect the organization and operations of companies in all industries. For some, the effect will be relatively slight; for others it will be great. If handled properly, advances in electronic data processing will provide great benefits.

The anticipated developments will tend to alter organization structure in many firms. The responsibilities and costs for information processing systems may be concentrated at one organization point and in the hands of fewer people. The job content in different company areas will change as the computer is used for calculating and determining action in many operations. Individuals at all levels will face greater opportunities, challenges, and difficulties. In some instances, it seems likely that fewer people will be used for a given volume of work.

The centralization of ADP equipment into public utilities, wherein many different types of users would be served, has been discussed as an ultimate development and as shown in Figure 8[6], it is predicted to have general acceptance and use by 1970. There are now many versions of this kind of centralization. Independently owned service centers are operated in the principal cities throughout the country. The Federal

Government has recently decided to set up a revolving fund to facilitate the establishment of ADP centers, equipment pools, and time sharing arrangements for Government agencies not desiring to operate their own equipment. A recent directive issued by the Bureau of the Budget and carrying the written benediction of President Johnson establishes the service centers mentioned above, requires each agency operating its own equipment to be responsible for its procurement, and provides for equipment standardization for all government owned ADP. This edict could have long range effects on organization in that certain functions could be centralized. For example, the Veterans Administration prepares data for checks each month which go to the Treasury Department where checks are written. The checks then go to the Post Office Department for sorting and mailing. The long range effects could be some consolidation of Federal Government Operations.

Section IV. SUMMARY

In the previous sections, an attempt has been made to provide a complete review of future ADP developments concerning equipment, workers, managers, and organization. During the next decade, ADP will "grow up." The next 10 years will mark somewhat of a deemphasis on machine development and concentrate on the perfection of exotic applications. The social contribution of ADP will be recognized as the masses learn to accept and use the technology. New ADP techniques will assume functions previously considered purely the estate of personal judgement. The impact of these developments will be the control issue of the period and will effect the organizational structure of the entire business enterprise. Our success in handling this new power could lead us to an entirely different world wherein man would enjoy a greater leisure than ever before.

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A synthesis of predicted Automatic Data Processing (ADP) developments in terms of their relationships to the total management of an organization, directed primarily to managers faced with a growing demand for better ADP utilization. ADP equipment capabilities likely to be available during the next decade are outlined in detail. Current techniques for the use of ADP systems and problems involved in installing improved future applications are discussed. A timetable is shown predicting the general acceptance and use of applications leading to maximum economical computer utilization. The ADP displaced worker situation is portrayed and actions for its alleviation are suggested. Statistics covering situations where ADP actually displaced workers are shown in graphic form. Managerial approaches to coping with systems integration, personnel training, and organizational structure evolving from an ADP influenced society are presented.

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