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A TECHNOLOGY ASSESSMENT METHODOLOGY

COMPUTERS-COMMUNICATIONS NETWORKS

HUGH V. O'NEILL

JUNE 1971 THE MITRE CORPORATION

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Volume 3

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COMPUTERS-COMMUNICATIONS NETWORKS

HUGH V. O'NEILL

Project No.: 1310

JUNE 1971

THE MITRE CORPORATION
WASHINGTON OPERATIONS

Department Approval: Martin V. Jones

MITRE Project Approval: William F. Mason

ABSTRACT

This paper describes a Pilot Computer Technology Assessment Study. This study has as its goal the development and illustration of technological assessment methodology and in addition, as a secondary objective, the investigation of certain salient segments of the general computer situation. This study, a MITRE funded and supported effort, is one of a set of six studies that MITRE recently completed on the subject of technology assessment. This report includes: a summary; task definition; technology descriptions; state of society/universe assumptions, attributes, and conditions; relevant impact areas; initial impact analysis; action options and recommendation for future research and development program; forecasts/projections, uncertainty and analysis of future impacts; and, conclusions and recommendations.

AN INDEX TO THE REPORTS IN THIS SERIES

VOLUME NUMBER	TITLE	NATURE OF VOLUME	THIS VOLUME IS:
1	Some Basic Propositions	Methodology	
2	Automotive Emissions	Pilot Study	
3	Computer-Communications Networks	Pilot Study	X
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FOREWORD

There is a growing public concern that new technologies should be introduced only after careful consideration of all beneficial as well as damaging impacts that the technology may have on our society. This concern has resulted from the fact that at times in the past the application of new technology has been based primarily on the direct benefits that a technology could generate without adequate concern for the associated potentially harmful social and ecological effects.

At the same time, thoughtful observers have recognized the hazards in moving frontally on this problem without a better understanding of the whole process through which new technology gets applied. On this basis there is a growing interest in the development of a methodology for making what have been called "technology assessments."

In May 1970, the Office of Science and Technology (OST), Executive Office of the President, and the MITRE Corporation undertook a jointly funded exploratory technology assessment project. The objective of this project has been to lay the foundations for a methodology that can be used to make assessment studies in many different fields of technology.

MITRE's contract with OST called for the writing of five reports - a methodological report and four pilot assessment studies. The four pilot studies cover automotive emission control mechanisms, industrial enzymes, mariculture (sea farming), and water pollution control (domestic wastes). Because of its considerable past work and continuing interest in electronics technology, MITRE also decided to undertake independently and finance solely from its own funds a fifth pilot assessment study on computer and communications networks.

Each of the pilot studies addresses a broad range of complex questions. Among these questions are: Where does the technology currently stand, in what directions does it seem to be developing, in what ways is the technology likely to be applied, what factors are likely to influence that application, what are likely to be the second level and tertiary consequences of the initial application, and what benefits and costs are likely to accrue from public efforts to alter either the technology applications or their consequences.

Although the pilot studies address a comprehensive list of topics, it is important that readers understand the objective of these studies and the reasons why they cannot be considered complete assessments. Because of limitations on time and resources, no aspect of the pilot studies could be carried as far as we would have liked. To the extent that time permitted, the pilot studies were used to derive and illustrate concepts, methods, and procedures that should go into full-fledged assessment studies. In many cases the data recorded in the pilot studies were not researched in depth. In some instances, we were obliged merely to identify the nature of major uncertainties which a complete assessment would aim to define thoroughly. In most cases, the analysis has been limited to a high level of aggregation if we felt that a finer-grain analysis would not contribute additional methodological insights. For instance, our analyses have been on a national scale rather than on a regional or lower geographic level.

In short, the objective of these pilot studies has been solely to help develop, test, and illustrate a generic technology assessment methodology, not to provide a substantive basis for public policy decisions in the fields of technology studied.

It should be pointed out when examining the computer pilot study that the conclusions and recommendations are somewhat general in nature and the projections represent impact directions and performance envelopes rather than specific numbers. This is mainly due to the fact that this was only a six man-month study, and that the following caveats obtain:

(a) There is considerable uncertainty regarding the various impacts of computer technology because of the basic impossibility of precisely predicting the future, even for relatively short time frames of 5 to 15 years.

(b) The majority of the data collected for this pilot study pertain only to the situation obtaining at the end of 1970. In such a highly dynamic field as computers new information continues to be generated on an almost daily basis; therefore, the information in this report should be updated to whatever time-frame is appropriate for any future use.

(c) Specific networks for gathering information relevant to the technology assessment of computers and their impacts have not been implemented at the present time; therefore, detailed specific data on many major issues are not available.

(d) There is honest confusion regarding the interaction of policy-making, regulatory, legislative, and enforcement organizations, due to the newness of the problems confronting them.

Although it is more important that a technology assessment answer certain fundamental questions than that it format its findings in any particular way, for pedagogical reasons we have expressed our approach to these fundamental questions in terms of seven basic steps. These steps are as follows:

(a) define the assessment task

(b) describe relevant technologies

(c) develop state-of-society assumptions

(d) identify impact areas

(e) conduct preliminary impact analysis

(f) identify possible action options

(g) revise and complete impact analysis

Because the methodology and the pilot studies were written concurrently rather than sequentially, we have not aimed for a complete correspondence between the methodology and the pilot studies, or among the various pilot studies, either in substance or material presentation. In the case of one pilot study (water pollution control) the chapters of the report have been organized quite differently even though the same substantive questions have been addressed as in the other pilot studies.

ACKNOWLEDGMENTS

Although individual authors are indicated for each of the project's reports, this has been an institutional project that has drawn on a number of MITRE Washington management and research staff who are not specifically identified below. Their contributions were incorporated as part of MITRE's regular technical review process.

Dr. Martin V. Jones was Research Coordinator for the study and of all reports. He also wrote the basic methodology, Volume 1.

The primary authors of the pilot studies were as follows:

Automotive Emissions	Mr. Willis E. Jacobsen
Computers and Communications	Mr. Hugh V. O'Neill
Enzymes (Industrial)	Mr. David H. Rubin
Mariculture (Sea Farming)	Mr. Robert C. Landis
Water Pollution	Mr. Victor D. Wenk

The Principal Investigator and author for the Computer Pilot Study wishes to express his special acknowledgment and gratitude to Dr. Ruth M. Davis of the National Bureau of Standards for guidance, reviews, comments, input documents and fruitful discussions. In addition, specific acknowledgment is given to Mr. Donald K. Pollock of The National Science Foundation (now with the Maritime Administration) and to Mr. Kenneth Showalter of The Office of Naval Research for reviews, fruitful discussions and input documents. In all cases, however, MITRE assumes full responsibility for the contents of the reports.

The participation of the following MITRE personnel should also be acknowledged: Mr. Harold J. Podell, for assistance in reading and summarizing a preliminary portion of the management literature; Mr. Frank E. Brooks and Mr. Warren S. L. Moy, for assistance in part of the editing; Mrs. Carol Paquette, for part of the early literature search; and Miss Cathy Carl for the major secretarial assistance.

MITRE wishes to thank the authors and/or publishers of the works cited in this report for their kind permission to use the material quoted.

SUMMARY

INTRODUCTION AND OVERVIEW

The primary objective of this study of computers is to assist in the development of a methodology for technology assessment. Lessons learned and problems encountered in this pilot study are part of the methodology development. One of the secondary objectives of this study is the integration and evaluation of extant knowledge about the computer field. Many references, quotations, and exhibits from the literature are presented as background information and to support or illustrate specific points, as well as to give a sample of the exploding volume of knowledge in the computer field. This report, therefore, can serve as a point of departure containing some of the elements of a plan for a more continuing effort for technological assessment of computers, which probably have had as great an impact on our society as any other technical innovation of the past quarter century. For instance, a list of over 2,000 kinds of applications of computers was published in the Computer Directory and Buyer's Guide issue of Computers and Automation, November 30, 1970.

The time-frame examined for the study is approximately 1965 to 1985 with the major emphasis on the future years. The technology investigated centered on computer-communications networks, where each node in the network may be a simple terminal or a minicomputer, as well as more advanced devices. This study is in part focused on the man-machine interaction for those who are not professional computer programmers. The primary consideration is for other professionals including doctors, lawyers, decision makers/managers, educators, systems analysts, and policy analysts. The programmer class of users is included indirectly from the point of view of certain problem areas, such as security/privacy. Some of the information contained in Chapter I is supporting material which illustrates the projected importance of computer-communications networks and serves to justify the scope of the task. Some examples of the supporting material obtained from the literature research are: a projection of a market of $260 billion cumulative for the 1970-80 time frame for computers-communications forming information systems; projection of an increase by a factor of 200 in the total number of computers coupled with communications in the decade of the 1970s; and a forecast indicating that by 1974 between one and two million terminals will be linked to computers. The general geographical scope is the United States.

TECHNOLOGY DESCRIPTION

A computer-based information processing system includes both information collection, storing and dissemination; and computation, simulation and modeling based upon appropriate data. A computer-based information network includes:

(a) Time-sharing: Sharing available computer time via terminals. Characteristically, the response time is such that the computer seems dedicated to each user.

(b) On-line multiple access: Pertaining to access to a computer by a number of users in such a way as to permit man-machine interaction. Usually the computer is operated in a time-sharing mode for this type of service.

(c) "Real-time": Simultaneousness. (See also Glossary and List of Acronyms, Appendix I.)

(d) Man-machine interaction: The interaction in the utilization of a computer whereby the user, through an on-line terminal, performs an input action which causes the computer to perform a sequence of operations and provide an output to the user. The user then, depending on the output, can perform another input action. The interaction can continue in an iterative manner.

(e) Remote access: Pertaining to communication with a data processing facility, and access to a computer, from a terminal that is distant from the facility.

(f) Computer network: A computer with various remote terminals, devices, etc.

(g) Networks of computers: A network with the major nodes themselves consisting of computers (including minicomputers) and ancillary equipment.

(h) Data banks, both private and public: Comprehensive collections of libraries of data.

The key to the technology assessment of computers is the realization that the computer is essentially the "forcing function" or "motor" that drives the computer-based network, and that it is the information and its analysis which are of fundamental importance for policy-making and implementation and for use by the medical, legal and educational professions, as well as commerce, industry, defense, and space programs. This means that the projected advances in computer-communications will present major innovative tools for society but that the measure of the computer impact will really be the changed nature of performance, in the cost-benefit sense, for the various professions and the changed nature of the life style and quality of life of the individual citizens. This change would present at least some measure of the impact of the security/privacy issue. It should also be pointed out that the impacts noted here are a representative set from a much larger list of impacts, both good and bad.

The reader is invited to refer to Chapter II for more detailed discussion of both computer and complementary technologies (communications, microforms), both present and projected. The exhibits from the literature which are included in that chapter present a general view of such issues as computers and communications capacities and capabilities. The advances in the technologies described in Chapter II will permit systems that will be capable of handling up to tens of thousands of on-line devices depending upon the overall systems design and the function of the individual on-line element. By 1980-85 there should also be significant advances in computer program systems dedicated to particular professions such as law, medicine, education and policy analysis. The advances in computers and communications projected for the 1980-85 time-frame will also permit the design and efficient implementation of distributed computer-based information networks and data banks. As a result of all these projected advances, a significant increase in the quality and quantity of health service, education, and administration of justice per resource expended should be possible. On the other hand, if sufficient attention to problems such as security and privacy is not forthcoming, then these same advances can potentially change the character of our life style in a very profound and unfavorable manner.

STATE-OF-SOCIETY/UNIVERSE ASSUMPTIONS, ATTRIBUTES AND CONDITIONS AND RELEVANT IMPACT AREAS

Societal conditions are reflected in a set of constraints upon the development and wide-spread introduction of computer technology. In many cases, these constraints will operate in both directions in an iterative manner, i.e., a particular societal condition may impede or accelerate the growth of technology and its application, and then in turn, be impacted upon by the innovative technology. This can produce a highly dynamic situation which will modify any initially rather static conditions. It is certainly not always intuitively obvious what the "steady state" condition will be. Therefore, the approach in this pilot study is to identify some of the major classes of assumptions and conditions including: values, goals, and priorities; gross economic considerations; major social problems and opportunities; institutional, political, and legal factors; and demographics.

The relevant impact areas include the same general topics given in the foregoing discussion, but emphasize the impact of computer-communications technology upon these areas. Both Chapters III and IV contain checklists of microlevel attributes, assumptions, and impacts. These checklists represent types of information which would be useful for specific cost/benefit analyses. Microlevel impacts provide a means for developing cost/benefit analyses relative to the macrolevel impacts. Sets of microlevel impacts quantify the broader impacts. The data collected in each of the microlevel impact areas can be used to measure the magnitude of the macrolevel impacts and thus permit associating dollar values and/or specific benefits with the broad impacts.

INITIAL IMPACT ANALYSIS, ACTION OPTIONS, AND UNCERTAINTY OF FUTURE IMPACTS

Chapter V includes a table of Representative Projected Impacts which were obtained through research and analysis of the literature. There are seventy (70) items listed which were obtained from a dozen separate sources. The chapter uses, as an example, an expanded statement of one of the special problems of computer-based information processing networks: the security/ privacy problem. Because of the time constraint, the discussion is limited to some of the groundwork necessary for more complete impact analysis. The impact on security and privacy is such that one should expect a serious level of abuse of the rights of citizens unless adequate safeguards are developed to provide the required protection.

Enough evidence from this preliminary analysis and judgment is presented to warrant the conclusion that a plan for organizing action options including a research, development and monitoring program and legislative and educational programs should be devised at the earliest time feasible. On the other hand, there is not enough coordinated specific detailed information to produce an entire program plan and, therefore, this information serves as a point of departure rather than as a sophisticated complete analysis.

Chapter VI describes relevant action options and recommends research and development programs aimed at guiding development of computer technology for the benefit of society. This includes a discussion of the logical arguments which support a research, development, and monitoring program. Chapters V and VI should be thought of as a closely connected set. Chapter VI investigates the consequences of the observations and information in Chapter V. The security/privacy problem is used to illustrate action options which can be addressed to the problems of computer-based technology. These include monitoring systems which gather information on problems and opportunities; control actions, including research and development programs and legislation; and obviating devices including educational and legislative programs. There are many other specific action options which can be considered. Antimonopoly regulations and laws making data available to all potential customers for information are only two of the additional action options among an extremely large set of possibilities. Chapter VI discusses the framework for research, development and monitoring systems which would give a rational basis for a whole spectrum of action options.

Chapter VII discusses one of the more difficult tasks encountered in technological assessment, i.e., the problem of making projections or forecasts for both the potential technological advances and the future interacting impacts of these advances and other societal conditions such as economic or political. The DELPHI Technique and the use of scenarios are emphasized, and some of the specific problems of uncertainty and attempts to be exhaustive and comprehensive are illuminated.

RECOMMENDATIONS

The listing below indicates the areas of consideration for the recommendations contained in the report. The reader should refer to Chapter VIII for a more complete statement of the conclusions and recommendations and for the rationale supporting the recommendations. There is uncertainty due to the caveats mentioned in the Foreword, and, because this was only a six man-month study, many of the following statements must reflect judgments rather than detailed analysis.

The following is an abbreviated description of the recommendations:

(a) A nucleus planning and analysis group should be formed on a permanent basis for the technological assessment of computers and their variety of complex impacts.

(b) Some of the classified military computer applications should be examined with appropriate security safeguards.

(c) An in-depth investigation of the computer's impact on employment should be performed. This investigation would include a monitoring system for the employment-unemployment situation and automation.

(d) Solutions, both technical and legal, must be found and implemented to lessen the problems of security and privacy of computer-based information systems, networks, and data banks in order that overall policy may be formulated soon.

(e) The copyright and patent problems for computer-based information systems should be the subject of further investigations -- both legal and technical.

(f) Large-scale experiments in the application of computers should be performed through the interaction of information technology organizations/agencies and mission-oriented organizations/agencies.

(g) A plan for a strong educational program for both the applications of computers and their fundamental concepts for all age groups should be devised.

(h) The specific organizational and policy implementation problems of the control and guidance of computer-based impacts should be addressed.

(i) A large-scale directed R & D program should be established. The following is an abbreviated sample from the list in Chapter VIII of the many objectives of such a program: voice input, at least to a limited extent; relatively inexpensive sophisticated terminals; improved capability for a verification and subsequent official certification of software performance; performance standards and measurements for hardware and software; and progress towards higher efficiency in the implementation of the highest level user-oriented computer languages/systems. The desired advances indicated in this list are from the point of view of service to the user or consumer rather than particular hardware advances which may be part of on-going R & D effort of the various computer vendors.

(j) Both a computer-based network or subnetwork and a major data bank should be implemented for the purposes of technological assessment in general and specifically for the purpose of technological assessment of computers-communications and their complex impacts.

(k) There should be further research and analysis to refine methodology for cost-performance (cost-effectiveness and cost-benefits) analysis for the complex computer network systems under consideration. This research and analysis would be an action option directed toward the problem of faulty cost benefit/performance projections, which in the past have resulted in scandalous cost overruns and lack of performance in the eyes of the user (customer or consumer).

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CHAPTER I

TASK DEFINITION

ISSUE

Computers are in the process of fundamentally altering the organizational structures of our institutions and the living conditions of our society. They have already deeply penetrated both industry and government and have strongly influenced the production and service functions. There is general agreement among the users that they have enhanced levels of service and decreased costs, have permitted achievement of otherwise impossible goals in other technologies (e.g., real-time solution of complex trajectories in the space program), have relieved analysts of lengthy, laborious numerical solutions of involved problems in mathematics and mechanics (problems which otherwise, in most instances, would not even be attempted), and have provided new services. But computers have also been identified as the source of major potential harmful impacts; the more critical ones include invasion of privacy, a potential rise in unemployment, and the general problem of due process under the law when an individual is dealing with a computerized system. Because potential impacts of computer technology are so extensive, there is a real need for a methodology that would permit comprehensive, future-oriented assessment studies in this field.

Purpose

The primary objective of this project is to develop a methodology for technology assessment through the case history/pilot study approach. This pilot study on computers is intended to provide a method for combining and evaluating computer-related knowledge and projections from many sources. Lessons learned and problems encountered in this partial technological assessment of computers contribute to the methodology development. This study surveys the field of computer technology with special attention given to societal impacts. The technical aspects of computers are touched on only to provide a foundation for analysis of these impacts. The computer pilot study does not intend to produce a comprehensive assessment of computer technology and, therefore, it need not go into great depths on all computer issues. Specific computer technology potential and problems were investigated in some depth only where it was appropriate. Although there may be certain new information presented in the study, the main or central thrust should be considered from the point of view of a longer range technical assessment plan. This paper should, therefore, serve as a point of departure containing elements for the plan of a continuing effort in conducting technological assessment of computers.

Scope

Although the task in general includes the vast field of computer technology, there are two external groundrules:

(a) The report is to be completely unclassified; hence, it cannot contain certain information pertinent to some major applications of advanced computer technology by the military; the intelligence community; command, control and communications organizations; and the AEC.

(b) Since this document has unrestricted dissemination, it does not contain proprietary information from any organization, corporation or affiliation. This omission has not been detrimental to methodology development.

TASK

The pilot study aims at providing an approach for integrating and evaluating the exploding volume of computer-related knowledge. Drawing heavily on available information, the study undertakes to:

(a) project current computer technology to some future date such as 1980 or 1985. By the 1980 to 1985 time frame the significant interaction of the computer with communications and the direct man-machine interaction will probably dominate the scene. This will no doubt include the "computer-based information network" and its various related concepts, with all its attendant benefits and problems.

(b) identify, analyze, and where appropriate, quantify the magnitude of potential applications of this projected technology.

(c) estimate the need for research resources for, and the criticality of impacts of, these technology applications on major areas of national well-being, including:

  (1) the joint problem of privacy and security for both the individual and the organization

  (2) the economic effect on labor

  (3) legal rights, "due process" and problems such as copyrights

  (4) diversity versus conformity with respect to citizen values and life style

  (5) provision of new business and consumer services and improvement of existing ones

  (6) reducing the costs of services

  (7) better utilization of certain scarce skills (e.g., medical personnel or decision-maker/analyst personnel)

(8) reducing the drudgery associated with menial tasks

(9) possible "dehumanizing" of consumer services

(10) undesirable side effects of scientism - an attitude that places undue emphasis on a quantitative and computational approach at the risk of oversimplifying a problem

(d) observe and analyze political, legal, administrative, and institutional obstacles that may impede the large-scale application of new computer technology. In order that the benefits of advanced computer-based innovations may be realized, the major problems of technological innovation must be addressed. These problems include social, psychological and political inertia. Some of the currently powerful vested interest groups will oppose the technical innovation with such vigor and resources that they may decrease the rate of progress significantly.

(e) identify and assess public policy options directed at maximizing the favorable impacts of projected computer technology and minimizing the adverse impacts. A variety of full-fledged computer-based information networks should have a major effect on communications, transportation, pollution, and probably other major national industries and problems. In the coming decades, communications systems must increase their capacity through such innovations as microwave networks and communications satellites in order to provide the required resources for a truly national or international information network.

METHODOLOGY

The fundamental problem for this study is that, on the one hand, the field of computer technology is diverse and there is an abundance of literature available; on the other hand, there are practical constraints imposed by the schedule and resources for this computer pilot study. If only a single topic is chosen there will be difficulty with respect to the impact and, in a certain sense, the credibility of the study. Yet, if an attempt is made to cover the general computer technology field without focusing on some specific major areas, then it is not feasible to exemplify a realistic technology assessment within the allocated resources. The resolution of this dilemma for the pilot study is as follows:

(a) cover the major computer areas in minimum depth

(b) choose one or two salient projected benefits or problems for a more thorough investigation

Exhibit 1 (Computer Technology Assessment Strategy) illustrates that this is a feedback process in which:

(a) Data (Preliminary Literature Search) is examined and evaluated and an initial judgment is made.

(b) Feedback from reviewers is examined and evaluated.

(c) This process is iterated until the results are judged satisfactory, with due consideration given to the resources available.

Definition

This study looks at computer technology in the context of computer-based information processing systems that will include both information collection, storage, and dissemination and computation, simulation, and modeling based upon appropriate data. A computer-based information processing network is characterized by:

(a) Time-sharing: sharing available computer time via terminals. Characteristically, the response time is such that the computer seems dedicated to each user.

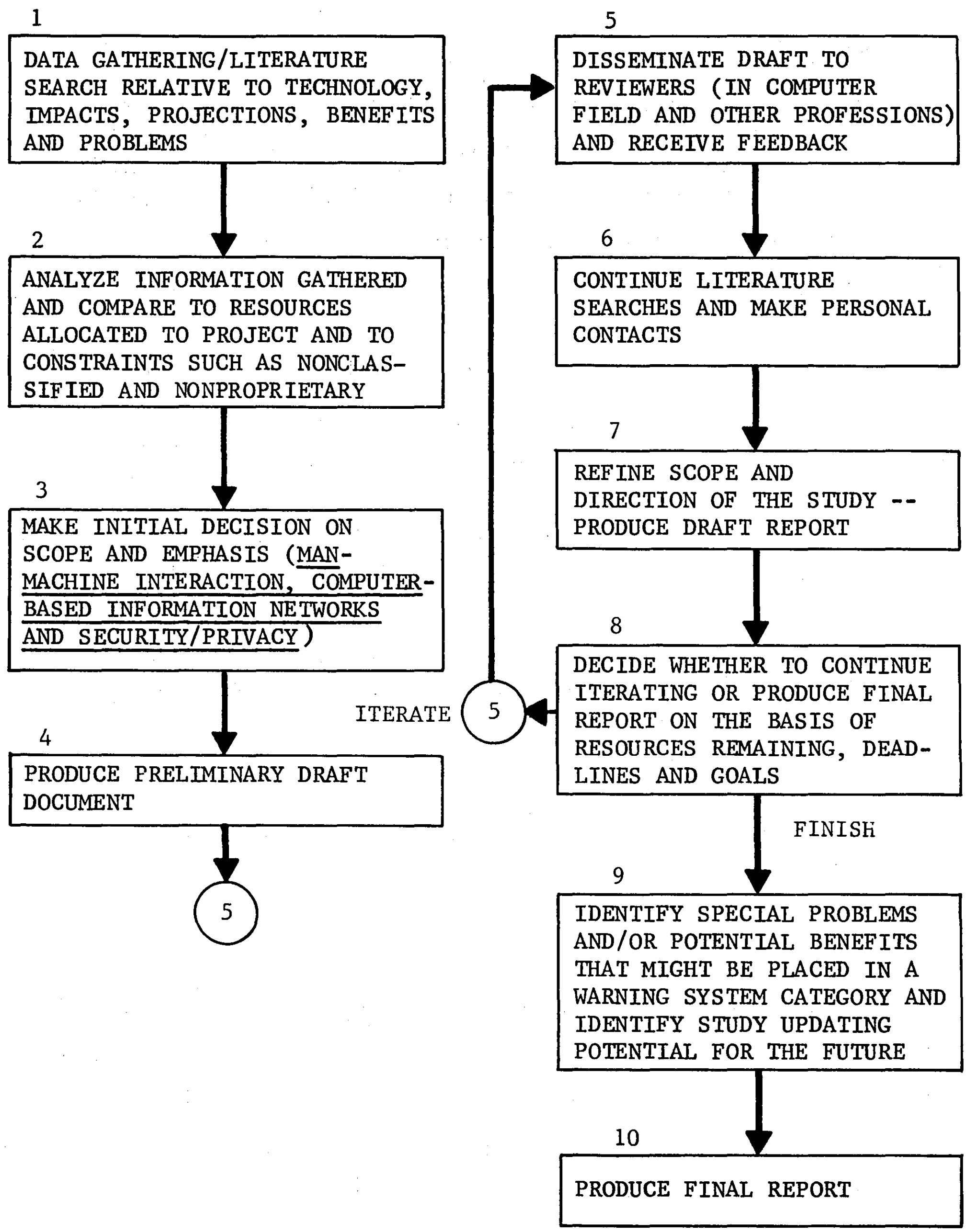


EXHIBIT 1
COMPUTER TECHNOLOGY ASSESSMENT STRATEGY

(b) On-line multiple access: pertaining to access to a computer by a number of users in such a way as to permit man-machine interaction. Usually the computer is operated in a time-sharing mode for this type of service.

(c) "Real-time": simultaneousness (see Glossary, Appendix I)

(d) Man-Machine interaction: the interaction in the utilization of a computer whereby the user, through an on-line terminal, performs an input action which causes the computer to perform a sequence of operations and provide an output to the user. The user then, depending on the output, can perform another input action. The interaction can continue in an iterative manner.

(e) Remote access: pertaining to communication with a data processing facility, and access to a computer, from a terminal that is distant from the facility.

(f) Computer network: a computer with various remote terminals, devices, etc.

(g) Network of computers: a network with the major nodes themselves consisting of computers (including mini-computers) and ancillary equipment.

(h) Data banks, both private and public: comprehensive collections of libraries of data.

In preparing this document it was not found feasible to eliminate all terminology which is peculiar to the automatic data processing field. A glossary and list of acronyms may be found in Appendix I.

Structure of Computer Networks

Computer-based information networks may be structured in one or more of the following ways:

(a) a general, U. S. Government-organized and administered network on a national and/or regional basis -- for the use of various government departments and agencies

(b) a department-oriented network operated by one of the major federal agencies/departments

(c) commercial, local time-sharing companies which may service many small businesses as part of their clientele

(d) a national or regional commercial network serving a relatively diverse set of customers

(e) an in-house network organized and controlled by a large corporation or international agency

(f) an in-house multiple access system for a particular installation, base, or large commercial building

In some cases the computer and communications may be owned and operated by a single organization, while some of the networks will probably use common-carrier lines.

PROBLEM DEFINITION AND SCOPE NARROWING

Since it is the objective of the pilot study to illustrate a methodology which may be useful for technical assessment in general, as well as in the computer field, the approach taken is as follows:

(a) choose a major, likely dominant, direction of the computer field in the time-frame projected (such that study resources are consistent with the objectives)

(b) proceed with technological assessment as follows:

(1) assess the current state of the art

(2) project the state of the art in terms of time frames or frame of the future

(3) identify and analyze the cost, benefits and problems to the society resulting from this technology

(4) outline specific policy options available in the present, intermediate, and future time-frame under study (This is a particularly important item in the chosen approach to technology assessment, since it is strongly recommended that such assessment be action-oriented.)

Time-frame Delineation

The time period 1980 to 1985 will be used as the major point of interest. However, the time-frame from approximately 1965 until 1980 will also be investigated.

The 1980 to 1985 time frame is close enough to the present to motivate political and individual involvement and yet far enough in the future so that a realistic implementation plan can be executed. The time frames 1965 to 1970 and 1970 to 1980 are also appropriate because of the data available and because this is the time (1970 to 1980) when realistic implementation must occur.

Technological Scope Narrowing

The central focus is on computer-based information networks comprising general-purpose digital computers, data communication facilities, and minicomputers or sophisticated display devices serving as terminals. When considering utilization of such networks, the emphasis for this study is on man-machine interaction. The breadth and diversity of computer applications are illustrated in Appendix II, A Sample Catalog of Computer Applications.

There are several reasons for the choice of a computer-based information network and its various related concepts.

(a) It contains the appropriate ingredients for a nationally relevant technological assessment. It holds benefits, such as better analysis of various program allocations by the government, and it also contains specific and representative dangers to the citizens such as invasion of privacy.

(b) The mainstream of recent advancement in applications of computers includes the chosen concepts; they can serve at least as representative of the computer field in general. The computer concepts chosen include special-purpose or dedicated computer-based information networks such as law enforcement networks or a computer network devoted to one large national or international corporation.

(c) A tremendous increase is expected in the interaction and coupling of computers with communications, another huge and vital segment of our economy. Dr. Ruth M. Davis noted in 1968:

> Time-sharing with all its ramifications demands the coupling of computers with communications. Time-sharing as yet is still in embryonic stages. Today there are an estimated 40,000 computers in the United States. One-half of one percent or approximately 200 of these are linked to communication lines. In the decade of the 1970's the number of computers in the United States is expected to almost double: it is anticipated that 50 percent of these will be linked to communication lines--an increase by a factor of 200 in the total number of computers coupled with communications.[1]

(d) The economic impact resulting from increased coupling of computers with communications should be considerable. One forecast using information from Business Week estimates that the joining of telecommunications to computers to form information systems will produce a market worth $260 billion, cumulative, between 1970 and 1980. As indicated in Reference (2), this includes the dollar volume spent for equipment, services, and resources.

Dan Cordtz, writing in Fortune, forecasted that by 1974 more than half of the 98,000 computers then in operation are expected to be linked by transmission facilities to 1,200,000 terminals.[2]

Early in 1969, General Electric Company prepared the estimates, shown in Exhibit 2, of revenues for communication-oriented computer installation (COCI).[3]

Geographical Scope Narrowing

In general, this pilot study is limited to the United States because our major policy options are relevant to this country. In addition, the United States has well over half of the world's computing systems at the present time. Recently published estimates of the distribution of computers as of January 1970 are given in the following table.[4]*

U. S.	62,500
Western Europe	24,000
U.S.S.R.	5,500
Eastern Europe	1,500
Other	12,500
World Total	106,000

Exhibit 3 illustrates, in capsule form, the scope of the computer pilot study. The headings, major and minor, in the exhibit refer to the amount of time spent during the study on a particular category. For example, the impacts listed have X's under the "Minor" column heading, but clearly the computer impact upon those categories is major. The amount of time allocated to any major coverage of a category was a maximum of 10 percent of the study; the X's under the "Minor" column represent significantly less time.

*From "Computers in Eastern Europe," Ivan Berenyi.

EXHIBIT 2
ESTIMATED DISTRIBUTION OF COMMUNICATIONS COMMON CARRIER REVENUES FROM COCI* BY USER INDUSTRY: 1970 to 1980
(BY BILLIONS OF DOLLARS)

YEAR	MANUFACTURING ($ Billions)	FINANCE ($ Billions)	SERVICES ($ Billions)	OTHER ($ Billions)	TOTAL CUMULATIVE ($ Billions)
1970	0.85	0.2	0.1	0.13	1.28
1972	1.6	0.3	0.14	0.24	2.28
1974	2.9	0.5	0.25	0.43	4.1
1976	4.9	0.9	0.43	0.72	7.0
1978	7.9	1.4	0.7	1.2	11.2
1980	12.5	2.2	1.1	1.8	17.6

*COCI is an acronym for "Communications-Oriented Computer Installations."

Source: GE Submission to the FCC, February 1969, re establishment of domestic non-common carrier communication satellite facilities by nongovernmental entities.

EXHIBIT 3
COMPUTER PILOT STUDY
SCOPE* OF STUDY

BREADTH* OF STUDY	DEPTH* OF COVERAGE			COMMENT
	Major	Minor	None	
Range of Technologies				
Computer	X			
Supporting	X			Communications, microform, TV
Competitive		X		
Range of Topics				
Technology Forecasts	X			Mostly intuitive, especially Delphi type
State of Society Conditions		X		
Action Options	X			R & D program plan and evaluation, monitoring systems, large scale experiments, legislative and educational programs
Groups Affected				
Beneficiaries		X		
Sponsors		X		
Third Parties		X		
Time Period Analyzed				
Extent Retrospective		X		Approximately 1965-70
Extent Futuristic	X			Approximately 1970-85
Types of Impacts				Impacts include all the major categories considered
Economic		X		
Social		X		
Environment		X		
Political		X		
Legal		X		
Institutional		X		
Other		X		Quality of life, educational, medical

* Scope measured by the amount of time spent on the breadth and depth.

EXHIBIT 3 (Concluded)
COMPUTER PILOT STUDY
SCOPE* OF STUDY

BREADTH* OF STUDY	DEPTH* OF COVERAGE			COMMENT
	Major	Minor	None	
Levels of Impacts				Impacts highly interactive, iterative and dynamic
Primary	X			
Secondary		X		
Tertiary		X		
Impact Measurements				
Qualitative Approximate or Precise		X		Approximate
Quantitative Approximate or Precise		X		Approximate
Uncertainty Analysis	X			

* Scope measured by the amount of time spent on the breadth and depth.

CHAPTER II

TECHNOLOGY DESCRIPTIONS

This chapter provides a general description of the technologies under consideration. The discussion is intended to present the correct order of magnitude or "ballpark" estimates of performance, rather than great technical detail. The reader is referred to the literature in the list of references for additional detailed information. In addition, such standard reports as the various Auerbach and Keydata publications are available for technical detail. The projections extrapolate current development to what will be technically and economically feasible by the 1980 to 1985 time frame. The methodology and analysis for projections are discussed in Chapter VII of this document.

Whenever one attempts to predict future events or development of a technology he should be strongly aware of the great uncertainties inevitably associated with such predictions, and he should temper his statements accordingly. The methodology for this study included examination of predictions made by a number of experts in the field; quite naturally, different individuals have differing opinions regarding what will happen during the next several years. Therefore, the graphs and numbers included in this report should be taken as only gross estimates of what might occur in the future. They are intended to describe the trend of developments and perhaps the envelope of future performance capabilities; they certainly should not be used for detailed system design purposes. Furthermore, nearly all of the data for this study was assembled by December 1970; some of the information came from references which were published in the late 1960's. Therefore, this study should be updated before it is used in future activities.

COMPUTER TECHNOLOGY

Current State of the Art

The state of the art for the purposes of this discussion will be divided into the following topics:

(a) hardware

(b) software

(c) techniques, concepts, and philosophy of operation

(d) special problems

(e) measures of merit, effectiveness, performance, etc.

Hardware

The general state of present performance for hardware can be characterized by the following:

(a) processors which will perform approximately three to ten million operations per second (still higher computation speeds can be achieved when needed with computing systems such as the ILLIAC IV and the CDC STAR that can perform several tens of millions of operations per second)

(b) primary memory storage on the order of one-half million to a million words (approximately 30-60 bits per word)

(c) cycle time of less than one-half microsecond

(d) capability for handling, in a practical manner, from dozens to hundreds of peripheral devices (depending upon controllers and communications channels)

(e) auxiliary storage devices that will store from several hundreds of millions of characters to several billions of characters, and, in some cases, a few trillion characters

(f) special sophisticated instruction sets

Software

The current software situation can be characterized by the following:

(a) many "higher level" programming languages such as FORTRAN, COBOL, GPSS, DYNAMO, etc.

(b) comprehensive computer operating systems

(c) ready-made data management systems capable of handling a large variety of file construction, update, retrieval and report generation functions

(d) many thousands of "canned routines," each dedicated to a particular application or set of applications

Techniques, Concepts and Philosophy of Operation

The current situation is characterized by the following:

(a) multiprogramming and multiprocessing which enable various user programs to share various system resources simultaneously, thus lowering processing cost per work unit

(b) multiple-access, on-line, remote, and time-sharing architecture which will currently permit upwards of several dozen simultaneous users with a reasonable response time, depending upon the individual function being performed

(c) the combining of several computers to form networks (developmental)

Special Problems

This area may be characterized by the following:

(a) reliability of software

(b) security and privacy problems

(c) overall standards (including compatibility/ transferability of software)

(d) efficiency of large sophisticated software systems

(e) the overall complexity of the systems

(f) software development costs

Measures of Merit, Effectiveness, and Performance

There are many measures and submeasures which might be considered. Some examples are:

(a) according to Herman Kahn and Anthony Wiener, the size of the memory space divided by the basic "add time," which roughly measures a computer's ability both to hold and to process information (5)

(b) some benchmarks or kernel problems, such as matrix inversion or sorting -- the time required as a function of the relevant parameters, e.g., the size of matrix

(c) the number of simultaneous users a system can handle with an appropriate (hopefully short) response time and as a function of the specific workload of each user

(d) "ease of use" of the system measured, perhaps, by the length of time that the user requires to respond during an interactive session with the machine as a function of system characteristics, and length of time required for a user to learn how to utilize the system

The state of the art in performance measures and projections is in great need of research and development, especially in view of the problems associated with measuring and predicting performance for the more advanced systems of the next decade. There are currently both hardware and software measuring systems and monitoring systems. Some of the performance measure objectives are:

(a) achieve a better balance between resident and transient routines

(b) identify areas of poor overlap of operation of the central processing unit and operation of input/output (I/O) devices

(c) locate bottlenecks that degrade system performance

(d) determine when and why peaking problems occur

(e) find out whether other I/O devices can be more effective

(f) balance the foreground and background in teleprocessing systems

(g) discover what routines use the greatest time[(6)*]

In The Economics of Computers[(7)] William F. Sharpe discussed various measures of performance and predictions of performance; it includes statistical mixes of instructions, Knight's formula for the measure of "computing power," and the relationship between higher level goals and systems characteristics. Allan Scherr in An Analysis of Time-Shared Computer Systems,[(8)] presents work performed several years ago on the older Project MAC Time-Sharing System. He includes his own method for metering the system, taking statistics on the system's performance, and modeling/simulating the system.

Future advances in technology will tend to alleviate the problem by the use of advanced and relatively cheap hardware to meter systems and to run sensitivity studies at a reasonable cost. However, new systems will also grow more complex with advancing technology and will be more difficult to model in any precise manner. At the same

---

time, users will expect better performance, evaluation, and prediction. One example of this situation may be found in the computer communication systems of the future. Knowing the response time of a time-sharing system will permit communication links to be freed for other use and the user brought back to his interaction with the system at a predicted time. This would save communication costs when one pays for the time the line is tied up, even if he is not using it continually. In addition, it would allow the communications system to treat many of the on-line users as relatively short telephone calls, rather than long-time calls. Since the telephone system is in general designed for many relatively short calls this can be an important factor with respect to overall communications service.

Great emphasis on throughput rates, balanced systems, high utilization for components may be quite important; but far more important is the increased performance or effectiveness of the human being who is being assisted by the computer system. This is an even more complicated performance measurement and evaluation problem. Research and development efforts directed towards increasing ease of use of the system and ease of learning operation of the system should be quite beneficial. These characteristics may be measured by the length of time it takes the user to accomplish a task relevant to him or to learn a new useful systems feature.

Projected State of the Art

The following points of information give some indication of what can be expected:

(a) The measure used by Kahn and Wiener, that of the size of the memory space divided by the basic "add time," has increased by a factor of ten every two or three years. While this cannot continue indefinitely, some of the other techniques of performance, such as parallel processing, will continue the overall acceleration of performance for a decade or more, although the rate of increase may not be constant.

(b) Exhibit 4 illustrates the general trend in the cost effectiveness of the central processor unit (CPU) plus primary storage.

(c) In addition, George B. Bernstein's A Fifteen Year Forecast of Information Processing Technology,[9] contains approximately 50 pages listing projected events. Many of these events were considered when making the projections in this chapter.

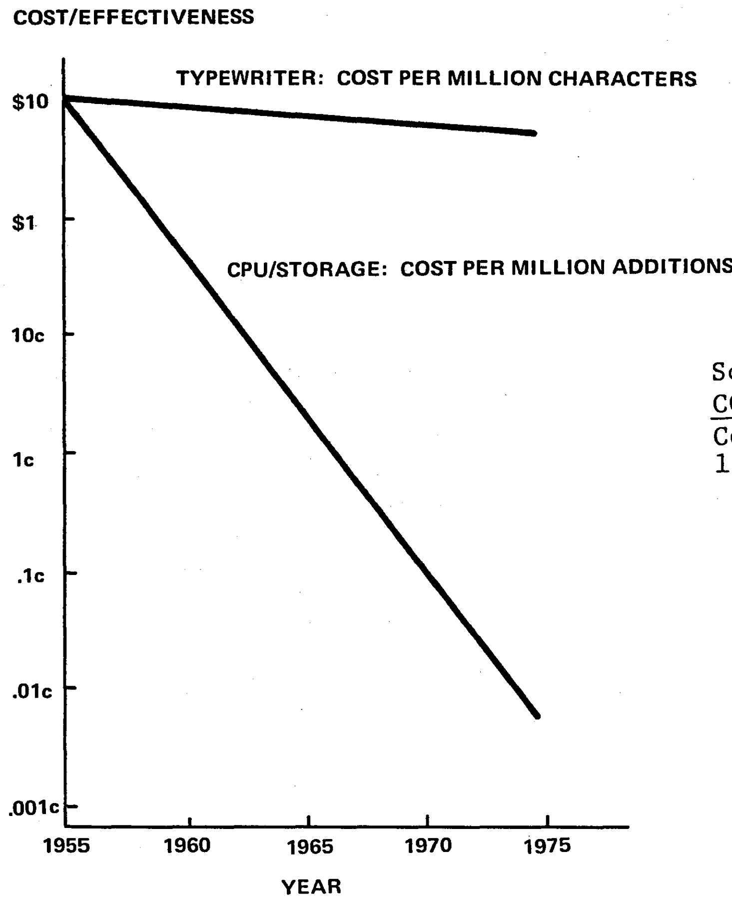
(d) The general state of projected performance for hardware will be more complicated when comparing performance measures with today's system measures. Not only will the basic hardware elements increase in performance but the overall design and operational philosophy will be significantly modified. This means that some of the measures, such as instructions per second, will have a somewhat different meaning. The following is an estimate of expected performance in the 1980 to 1985 time frame:

  (1) Processor systems will perform at an approximate range of 100 million to upwards of a billion or more instructions per second. This would be a function of the sophistication of the instruction set, the number of CPU's, designs such as parallel/array and pipeline, etc.

  (2) The information storage systems will have a hierarchy extending from the ordinary systems of today up through extremely fast and large memory subsystems; cycle times can be expected to be measured in nanoseconds.

  (3) The computer systems will be capable of handling up to tens of thousands of on-line devices depending upon the overall systems design and the function of the individual on-line element.

Availability of such computing power will allow the performance of useful calculations which are not feasible today. An advanced computer, ILLIAC IV, being built by the University of Illinois, will be capable of executing



Source: THE ECONOMICS OF COMPUTERS by W. F. Sharpe, Columbia University Press, 1969, p. 323.

ESTIMATED TRENDS IN COST/EFFECTIVENESS. SOURCE: PAUL ARMER, "COMPUTER ASPECTS OF TECHNOLOGICAL CHANGE, AUTOMATION AND ECONOMIC PROGRESS," A REPORT PREPARED FOR THE NATIONAL COMMISSION ON TECHNOLOGY, AUTOMATION AND ECONOMIC PROGRESS, SEPTEMBER 1965, p. 6.

EXHIBIT 4
THE TREND IN COST EFFECTIVENESS
OF COMPUTER SYSTEMS CENTRAL PROCESSOR
UNIT AND PRIMARY STORAGE COMPONENTS

over 100 million instructions per second. D. L. Slotnick in "The Fastest Computer," gives a number of examples of calculations requiring such power. One of them is described in the following quotation from his article.*

> A quite different assignment for ILLIAC IV is numerical weather prediction, which early computer theorists such as John von Neumann regarded as one of the important motivations for their work. Numerical techniques developed over the past two decades are now in daily use and yield good results for periods of from 24 to 48 hours. These techniques involve the simulation of complex atmospheric processes by a mathematical model that combines extensive knowledge of the relevant physical processes with sophisticated mathematics and advanced computer technology... .
>
> The complexity of these models is ilustrated by the operational model of the atmosphere used by the National Weather Service in its daily forecasts. The atmosphere over the Northern Hemisphere is represented by six horizontal slices ranging from sea level to the stratosphere. Each slice contains 3,000 points at which initial values of wind velocity, temperature and pressure are inserted. The computer then applies the appropriate equations to predict what the velocity, temperature and pressure will be in the future at 10-minute intervals. A 24-hour forecast requires about an hour of computing time on a computer that can execute 300,000 instructions per second, or more than a billion instructions in all.
>
> If the distance between the grid points were to be halved, the number of grid points would be quadrupled and the computer time needed for a 24-hour forecast would be increased eightfold. In other words, a third of a day would be consumed merely in making a 24-hour prediction. If the model yields significantly better short-range predictions than the 3,000-point model now

*From "The Fastest Computer," D. L. Slotnick.

in use, there is a good chance that numerical forecasts can be extended to five days with an accuracy comparable to that of the 48-hour forecasts now being generated.

The actual computer techniques of weather forecasting can be advanced by testing them on ILLIAC IV. Until now investigators have been reluctant to experiment with a new predicting technique when it might involve many computer simulations, each of which could take up to 100 hours of computing time. When ILLIAC IV can reduce the running time from 100 hours to one hour, extensive experimentation will become feasible.[10]

(e) The general projected state of software for the 1980 to 1985 time frame is the following:

(1) many advanced and "easy-to-use" languages and "canned routines" dedicated to particular professions such as law, medicine, education and decision-making enterprises (This software will be heavily user-oriented and essentially speak the user's language rather than the programmer's language.)

(2) extremely sophisticated operating and data management systems which will, in the general case, perform in such a manner that the user will not know whether certain programs or subsets of the data bank are being operated from one type of storage medium or another

(3) a possibility that the greater percentage of what we call software (i.e., computer programs) will actually be part of what we now call hardware of the system.

(f) As regards techniques, concepts, and philosophy of operation, the situation in the 1980 to 1985 time frame will have as its main philosophy of operation a distributed computer-based information network/data bank.

(g) Minicomputers (sophisticated terminals, intelligent terminals, sophisticated electronic desk calculator)--both the capability and the prevalence of these devices should be enormously expanded in the time frame under consideration, i.e., 1980 to 1985. These devices should be capable of performance of the order of magnitude of medium to larger computers of the 1965 to 1970 time frame. The prefix "mini" is a relative term with respect to physical size (volume), cost, and performance relative to the state of the art of a particular time frame. The device in question, whether called minicomputer, sophisticated terminal, or intelligent terminal, in the 1980 to 1985 time frame should be capable of the following:

(1) operation in accordance with an internally stored program

(2) ordinary arithmetic operations

(3) probable inclusion of floating point and elementary mathematical and statistical calculations

(4) performance of a certain level of encryption when appropriate

(5) control of fairly sophisticated input/output devices, audio visual displays, etc.

(6) checking sophisticated programs for at least the more obvious errors before the programs are sent to the shared computer-based information processing network system

(h) There will be a range in the performance of the minicomputers; some of them may serve as central units for many relatively simple terminals in what might be called a "mininetwork."

The following quotation indicates the present and projected financial picture of the minicomputer to the mid 1970's:

> It is not a simple matter to crash the growth-and-profit party in the computer industry, as so many companies have learned. A ticket at the main door means competing with International Business Machines Corp. and costs hundreds of millions in venture capital. But tiptoeing in the side door when the major systems makers are not looking sometimes works. In the last four years, at least 75 manufacturers

> have done so with minicomputers--small machines priced from $3,000 to $25,000.
>
> Some of the newcomers seem to have staying power, though many will get bounced. Together in the computer field, they have built a subindustry that grew from $25-million a year in 1967 to well over $250-million in 1970. Through the business downturn that caused a drop in the over-all dollar value of computer shipments last year, the minis maintained a 30% annual growth rate. And, despite a swift, continuing price erosion, even the cautious analysts of the industry expect sales of minis to top $1-billion a year by the mid-1970's.
>
> Their bullish mood got an added lift when IBM entered the minicomputer market late last year.(11)

As of August 1970 there are more than 7,500 units in use.(12)

The impact of the minicomputer is substantial even today. During the 1975 to 1985 time frame it should increase to such an extent that the man-machine relationship will be enhanced significantly by the combination of the individual with his "intelligent" terminal/minicomputer. Minicomputer stand-alone capabilities will be enhanced significantly when coupled with the information processing network.

In summation, the minicomputers will be capable of performing most of the arithmetic workload at the remote site itself and of serving as an easy-to-use terminal to the large network and data bank. These systems will be capable of performing many of the tasks that are performed by today's computing centers.

<u>Breakthroughs and Directed Research and Development Needed, Including Technical, Institutional, and Economic</u>

The desired advances indicated in this list are from the point of view of service to the user or consumer rather than particular hardware advances which may be part of on-going R & D effort of the various computer vendors. Breakthroughs and directed research and development which would be instrumental for achieving effective man-machine interaction and "information networks" are the following:

(a) voice input, at least to a limited extent and at non-prohibitive cost to the user

(b) relatively inexpensive sophisticated terminals/minicomputers

(c) improved capability for verification and subsequent official certification of software performance (This research and analysis is directed to attacking the problem of "debugging completely" or at least with some acceptable certification, large complex software systems.)

(d) increased acceptance on the psychological and political level of the most innovative technology

(e) decrease in the cost of software development

(f) decrease in the cost of reliable, multiple-font optical character readers

(g) a practical and economically viable solution to the security/privacy problem

(h) advances in user-oriented modeling/simulation and basic understanding of some of the relationships in the complex "real-world"

(i) performance standards and measures for hardware and software

(j) advances in methods for educating programmers for performance on advanced systems

(k) progress towards higher efficiency in the implementation of the highest level user-oriented computer languages/systems (These languages/systems are closest to the nonprofessional programmer user and, although simple to use, may cause significant complexity and possible inefficiencies from the point of view of the internal system.)

Environment Characteristics

Following are some items which are exogenous to the technology itself, but which will have great influence on the future development of computer-communications networks:

(a) rulings of government regulatory agencies and government policies with respect to computers and communications

(b) legislation with respect to protection of privacy in data banks

Physical-Resource Data

Exhibits 5, 6, and 7 illustrate some computer-communications service networks. These figures illustrate, first, the currently operational FBI National Crime Information Center (NCIC) law enforcement network; second, the Department of Defense, ARPA, experimental development network; and third, a currently operational commercial CDC network. Other examples of present networks include the following:

(a) The GE commercial network

(b) the NASA network

(c) The AEC network at the Lawrence Radiation Laboratory, Livermore, California

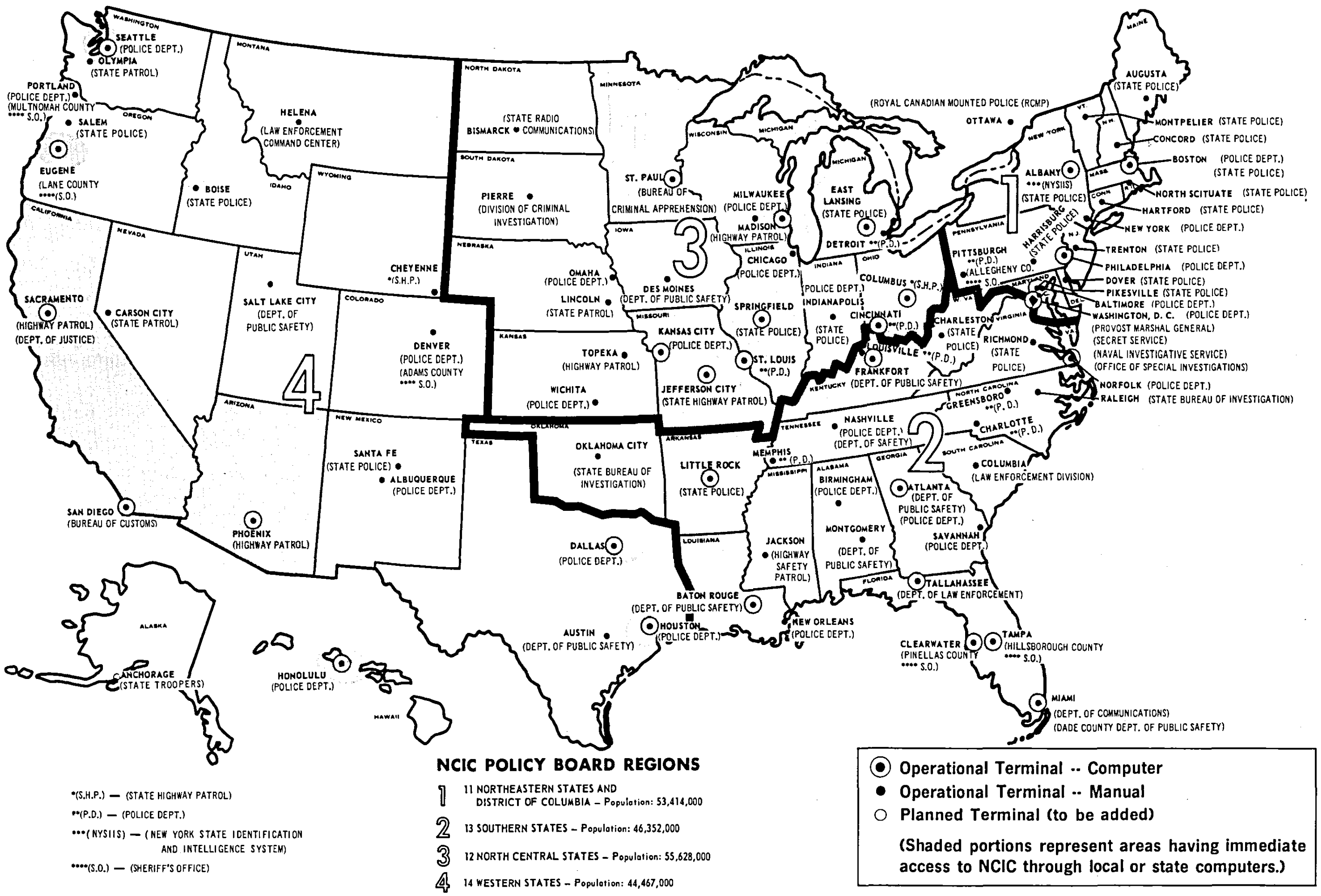
Operational Data

The new technology will be offered by:

(a) the computer and communication vendors including IBM, CDC, UNIVAC, RCA, Honeywell Information Systems, AT&T, etc.

(b) companies such as UCC, CSC and others that are forming their own computer-communications commercial network systems

(c) the federal government and its various departments, as well as the state and local governments (for internal government use)



Source: Federal Bureau of Investigation, November 1970

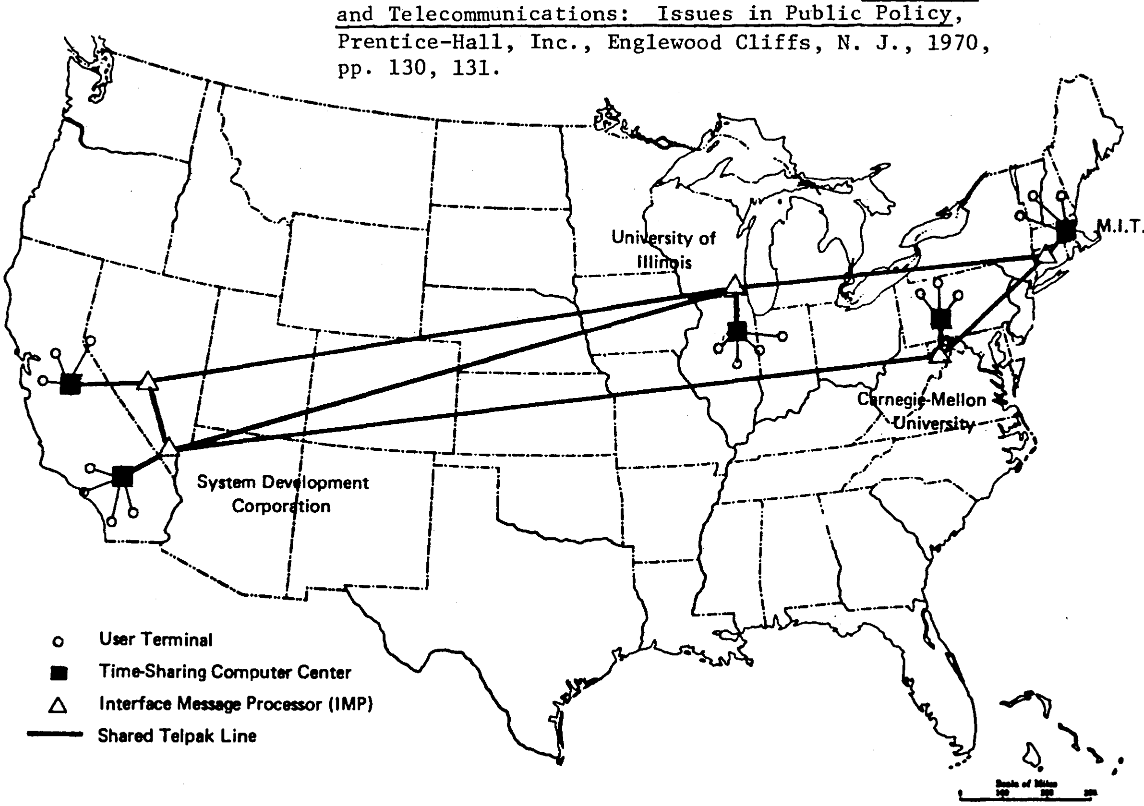
EXHIBIT 5
NCIC NETWORK

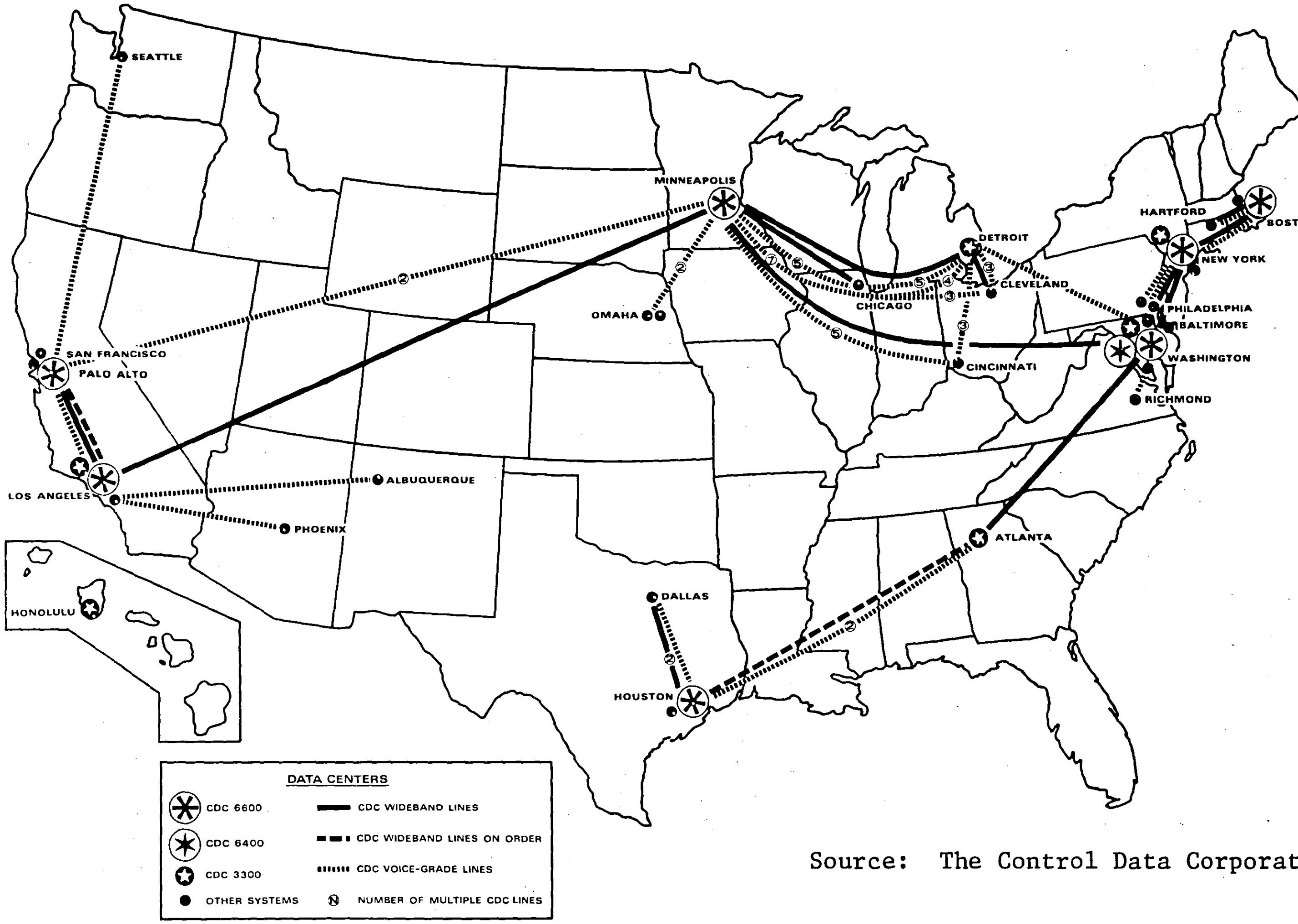
EXHIBIT 6
ARPA NETWORK (GREATLY SIMPLIFIED)

TIME-SHARING COMPUTER CENTERS TO BE INTERCONNECTED BY THE ARPA NETWORK

Organization	Site Location	Computers
Carnegie-Mellon University	Pittsburgh, Pennsylvania	UNIVAC 1108, IBM 360/67, G-21
Dartmouth College	Hanover, New Hampshire	GE 635
Harvard University	Cambridge, Massachusetts	SDS 940, IBM 360/50, DEC PDP-1
Massachusetts Institute of Technology	Cambridge, Massachusetts	IBM 7094, DEC PDP-6/10, GE 645
Stanford University	Stanford, California	DEC PDP-6/10
University of California at Berkeley	Berkeley, California	SDS-940, SCC 6700
University of California at Los Angeles	Los Angeles, California	SDS Sigma-7
University of California at Santa Barbara	Santa Barbara, California	IBM 360/50
University of Illinois	Urbana, Illinois	Burroughs B-6500/ ILLIAC IV
University of Michigan	Ann Arbor, Michigan	IBM 360/67
University of Utah	Salt Lake City, Utah	UNIVAC 1108
Washington University	St. Louis, Missouri	Special Equipment
Advanced Research Projects Agency	Washington, D. C.	DEC 338
Bell Telephone Laboratories	Murray Hill, New Jersey	GE 645
Bolt Beranek & Newman, Inc.	Van Nuys, California	SDS 940, DEC PDP-10
M.I.T. Lincoln Laboratory	Cambridge, Massachusetts	TX-2, IBM 360/67
RAND Corporation	Santa Monica, California	DEC PDP-6, IBM 1800
Stanford Research Institute	Palo Alto, California	SDS 940 (2)
System Development Corporation	Santa Monica, California	IBM 360/50-65

Source: Stuart L. Mathison and Philip M. Walker, Computers and Telecommunications: Issues in Public Policy, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1970, pp. 130, 131.





Source: The Control Data Corporation.

EXHIBIT 7
CYBERNET NETWORK

Users

The range of potential users of computer-based information networks is enormous and would include almost everybody from the President to the average housewife. Some examples of other users are: medical doctors, lawyers, educators, decision makers, and policy analysts. It is expected that various age groups and many in the professions will be major users and the geographical distribution will be a function of both population density and professional distribution.

Time Phasing

During the decade of the 1970's both local time-sharing systems and networks of computer systems will be further developed technically and accepted by a substantial number of potential users. By 1980 to 1985 the network concept should be in the full application stage; i.e., the technological innovation will have been accepted by a substantial number of potential users. In addition, some of the institutional barriers created by social, political, and psychological inertia will have been overcome, and the general operational performance will be in a fairly substantial state of user-oriented development. Additional information on time phasing is presented in the following sections.

Financial Information

Detailed planning data on RDT&E investment and operational costs are usually of a proprietary nature; but general overall costs and plans have been described in the open literature. Some specific numbers pertaining to various computer/information network systems are illustrated in Exhibit 8.

It should be noted that this table is for illustrative purposes only and that some of the organizations have already significantly

EXHIBIT 8
RECENT ANNOUNCEMENTS OF MAJOR SIGNIFICANCE TO THE COMPUTER UTILITY CONCEPT

February 1969	Travelers Corp. establishes a subsidiary, TravCom, Inc., to provide "total information systems" to medical institutions, local government operations, educational institutions and businesses, but concentrating initially on psychiatric hospitals. "The company is prepared to invest $50 million in the subsidiary and expects it to achieve annual sales of at least $100 million within 5 years." (Wall Street Journal Feb. 26, 1969)
February 1969	Control Data Corp. inaugurates a national computer network called Cybernet linking computers in 25 cities including six 6600 computers. The system valued at $50 million will provide time-sharing and remote computing services. Cybernet's "sales strategy will be to displace existing installed computers and to absorb additional workload." (Business Week, Feb. 8, 1969)
January 1969	Honeywell, Inc., announces its entry into the electronic data processing services field. "The new division will offer shared computer time, batch processing services, contract software and programming assistance and customized software packages." A company executive "cited industrial surveys indicating that the information services field would nearly triple in volume to about $27 billion in 1972 from its 1967 level of $950 million." (New York Times, Jan. 29, 1969)
December 1968	Greyhound Corp. enters the time-sharing field through its subsidiary, Greyhound Computer Corp. The company's initial success had been in the computer leasing field. (Business Automation News Report, Dec. 23, 1968)
November 1968	"Westinghouse has begun offering remote batch processing service to outside users through its Information Systems Laboratory . . . Certain Westinghouse-developed engineering design analysis programs will also be made available. Plans call for the addition of other time-sharing services." (Datamation, November 1968)
August 1968	Computer Sciences Corp. makes its move toward establishing a nationwide time-sharing network. Credit searching and reporting and conversational engineering/scientific computation will be the first services to be offered at 20 computer centers across the U. S. CSC ordered Univac 1108 equipment worth an estimated $50 million. (Datamation, Aug. 1968)
August 1968	NCR announced that it would double the number of its on-line data centers to 10 in a $3 million expansion program. The on-line data centers serve banks and savings and loan companies. With centers other than on-line the company has 25 in the United States-Canada network. Abroad there is another network of 31 data centers. (Datamation, August 1968)
May 1968	ITT announces its time-sharing system called Reactive Terminal Service with plans to make the service available throughout the nation within 18 months. (Data Systems News, May 13, 1968)
April 1968	Univac reveals its plans for a nationwide network of computer service centers that will be linked via communications lines, integrating large and small computers. "Services to be offered include designing, programming and processing specific data processing applications for customers." (Computers and Automation, April 1968)
March 1968	General Telephone and Electronics declares its intentions of setting up seven regional data processing service bureaus throughout the country. "Much of their workload will come from GT&E operating companies but an apparently substantial percentage of available computer time will be sold to banks, credit unions, and other financial institutions . . . The bureaus will provide both local and on-line dp services." (Datamation, March 1968)

Source: Ralph L. Zani and William M. Zani, "Towards the Computer Utility: Evolution, or Revolution," Datamation, October 1969, p. 132 (reprinted with permission of Datamation ®, copyright Technical Publishing Company, Barrington, Illinois 60010, 1969).

modified their plans. Nonetheless, it shows the order of magnitude of the costs involved. A specific illustration can be drawn from GE's involvement in the time-sharing business.

> ...Recently the company announced that it would spend at least $100 million in the next five years to expand its new time-sharing computer network, which now services forty-two cities nationwide through a single Cleveland "supercenter." GE intends to widen its coverage to a total of 150 cities in 1971 by opening two more centers in Los Angeles and Teaneck, New Jersey. The company has successfully tested a network link to London via satellite, and hopes to expand the system to a number of cities overseas.
>
> GE has already invested $100 million in time-sharing equipment alone and holds a third of the $200-million-plus U.S. market.(13)

Another example comes from AT&T's effort to build a large-scale comprehensive computer-based network information system.

> AT&T also uses commercial computer extensively for internal business data processing. It has approximately 600 such general purpose computers installed, and has established a 500-man task force to develop a comprehensive computer-based, internal Business Information System (BIS)* (*For background on the BIS concept, see AT&T, The Bell System's Approach to Business Information Systems, New York, 1965.)(14)

COMPLEMENTARY TECHNOLOGY

The technology component that complements this computer technology assessment includes the following: communications, microform, video (TV), graphical display, and facsimile.

Communications Technology

Present Time-Frame

The following points of information are presented as a summary:

(a) Relatively slow speed (e.g., teletype speed) and voicegrade communications are plentiful and reasonably economical, at least for local communications. There is, however, a question of reliability.

(b) Fifty-kilobit lines have been made available for current remote multiple-access systems.

(c) The cost of long-distance communications is still a significant bottleneck.

(d) Encryption devices can be properly interfaced with present communication systems for most reasonable rates of data transfer.

(e) The interaction between and among the U. S. Government agencies, industry suppliers of communication services, user organizations, computer and network vendors on the questions of policy constraints and costs is a dominant consideration.

(f) The adequacy of communication service in a computer information network at the present time can be characterized by Exhibits 9[15] and 10[16].

(g) The relationship between the theoretical capacity or maximum rate of information transmission and actual implementation is presented in the following quotation:

> According to theory (the Shannon-Hartley Law) the capacity, or maximum rate of information transmission at an arbitrarily small error rate, of a bandlimited communication channel is determined by its bandwidth and by the signal-to-noise ratio present on the channel.* Using efficient signal encoding procedures and other techniques to obtain high signal-to-noise performance, data transmission rates of more than ten times channel bandwidth, that is, 30,000 bits per second over a 3000 Hz voice grade telephone channel, are theoretically possible. In practice, however, such speeds are not attained, due to the limitations of the state of the art, and the complexity and consequent cost of

EXHIBIT 9
CURRENTLY AVAILABLE COMMON CARRIER COMMUNICATIONS OFFERINGS USEFUL FOR DATA TRANSMISSION

National switched networks	Data transfer rate in bits per second
Telegraph grade	
TWX (AT&T Tariff F.C.C. No. 133)	45-150
Telex (W.U. Tariff F.C.C. No. 240)	50
Voice grade	
Message toll telephone (AT&T Tariff F.C.C. No. 263)	1,200-2,000*
WATS (AT&T Tariff F.C.C. No. 259)	1,200-2,000*
Broadband exchange (W.U. Tariff F.C.C. No. 246)	1,200-2,400
Dataphone 50 (AT&T)	50,000
National leased network (AT&T Tariff F.C.C. No. 260, W.U. Tariff F.C.C. No. 237)	
Telegraph grade	45-180
Voice grade	1,200-9,600*
Broadband	
12 voice channels (Series 8000)	50,000
60 voice channels (TELPAK C)	250,000
240 voice channels (TELPAK D)	500,000

*One of the factors limiting the data transfer rate on a given communications channel is the performance characteristics of the modem interface device at the endpoints of the line. In the near future, commercially available modems will allow data transfer rates of 3,600 bps on switched, voice-grade lines. Modems operating above 4,800 bps on voice-grade lines are infrequently used today because of their high cost and sensitivity to time-varying channel characteristics.

Source: Stuart L. Mathison and Philip M. Walker, Computers and Telecommunications: Issues in Public Policy, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1970, p. 155.

EXHIBIT 10
COMPARISON OF DATA PROCESSING EQUIPMENT OPERATION SPEEDS WITH AVAILABLE TRANSMISSION LINE SPEEDS

Data processing equipment[1]	Operating speed	Available transmission line	Present transmission line speed
	(bits/sec.)		(bits/sec.)
Card reader			
300 CPM[2]	3,200	Voice: switched	2,000
		leased	2,400
600 CPM	6,400	Voice: switched	2,000
		leased	2,400
		Broadband:	
		leased only	50,000
1000 CPM	10,600	Voice: switched	2,000
		leased	2,400
		Broadband:	
		leased only	50,000
Card punch			
300 CPM	3,200	Voice: switched	2,000
		leased	2,400
500 CPM	5,300	Voice: switched	2,000
		leased	2,400
Paper tape reader	75	Telegraph or Teletypewriter: switched and leased	110/180
	2,800	Voice: switched	2,000
		leased	2,400
	4,000	Voice: switched	2,000
		leased	2,400
		Broadband:	
		leased only	50,000
	8,000	Voice: switched	2,000
		leased	2,400
		Broadband:	
		leased only	50,000

Source: Booz, Allen & Hamilton, Inc., Study of Interdependence of Communications Services, quoted in Mathison and Walker, *op. cit.* pp. 157-159.

EXHIBIT 10 (Continued)
COMPARISON OF DATA PROCESSING EQUIPMENT OPERATION SPEEDS
WITH AVAILABLE TRANSMISSION LINE SPEEDS

Data processing equipment [1]	Operating speed	Available transmission line	Present transmission line speed
	(bits/sec.)		(bits/second)
Paper tape punch	75	Telegraph or Teletypewriter: switched and leased	110/180
	800	Voice: switched	2,000
		leased	2,400
Printer			
300 LPM [3]	6,000 to		
600 LPM	10,600	Voice: switched	2,000
		leased	2,400
		Broadband: leased only	50,000
1000 LPM	19,400	Voice: switched	2,000
		leased	2,400
		Broadband: leased only	50,000
Teletypewriter	45-150	Teletypewriter: switched and leased	45-150
Cathode ray tube	8,000	Voice: switched	2,000
		leased	2,400
		Broadband: leased only	50,000
Magnetic tape transport	150-3,000	Teletypewriter: switched and leased	110/180
		Voice: switched	2,000
		leased	2,400
	120,000	Broadband: leased only	50,000
		Broadband (Telpak C) leased only	250,000

EXHIBIT 10 (Concluded)
COMPARISON OF DATA PROCESSING EQUIPMENT OPERATION SPEEDS
WITH AVAILABLE TRANSMISSION LINE SPEEDS

Data processing equipment[1]	Operating speed	Available transmission line	Present transmission line speed
	(bits/sec.)		(bits/sec.)
Magnetic tape transport (continued)	240,000	Broadband (Telpak C) leased only	250,000
	480,000	Broadband (Telpak D) leased only[4]	500,000
	720,000	Broadband (Telpak D) leased only[4]	500,000
	960,000	Broadband (Telpak D) leased only[4]	500,000
	1,440,000	Broadband (Telpak D) leased only[4]	500,000
	2,720,000	Broadband (Telpak D) leased only[4]	500,000
Disk units	1,248,000	Broadband (Telpak D) leased only[4]	500,000
	2,496,000	Broadband (Telpak D) leased only[4]	500,000
Drum units	1,000,000	Broadband (Telpak D) leased only[4]	500,000
	8,000,000	Broadband (Telpak D) leased only[4]	500,000
Central processors	2,000,000	Broadband (Telpak D) leased only[4]	500,000
	6,400,000	Broadband (Telpak D) leased only[4]	500,000
	16,000,000	Broadband (Telpak D) leased only[4]	500,000

1. Includes most commonly used data processing equipment.
2. CPM: cards per minute
3. LPM lines per minute
4. There is no standard modem tariffed for use with Telpak D service at this time. Modems for Telpak D require special order from the common carrier.

encoding equipment necessary to approach theoretical transmission limits. For example, on a leased voice grade line the maximum data transfer rate actually possible today is 2400 bits per second, using modems available from the carriers, or 9600 bits per second using modems available from several independent manufacturers.

*(See e.g., James Martin, Telecommunications and the Computer, Englewood Cliffs, N. J. Prentice-Hall, Inc., 1969, Chapter 11; also John M. Wozencraft and Irwin M. Jacobs, Principles of Communications Engineering, New York, John Wiley & Sons, Inc., 1965 Chapters 5 and 6.)(17)

Projected State of the Art

By the 1980 to 1985 time frame the following conditions should illustrate a summary of the state of the art:

(a) Communications capability will be increased through communication satellites. An indication of the interest in domestic communication satellite systems is the number of applications to the FCC. This list currently includes: 1) Communications Satellite Corporation (COMSAT); 2) AT&T/COMSAT: 3) Western Union Telegraph Corporation; 4) RCA Globecom/RCA Alascom; 5) Microwave Communications, Inc./ Lockheed Aircraft Corporation; 6) Hughes Aircraft Corporation/General Telephone System; 7) Western Telecommunications, Inc.; 8) TV networks (tentative); 9) Fairchild-Hiller Corporation.(18)

(b) Microwave systems will provide greater capability.

(c) Digital networks will present considerable capability. (Even today the Bell System T-Carrier system has considerable capacity as revealed in the following quotation.):

> Bell has installed 200,000 circuit miles of T-1 carrier, which has a capacity of 1.544 megabits per second. T-2 carrier

will transmit 6.3 megabits per second over two telephone wire pairs and will be introduced in 1970. T-4 carrier will transmit 600 megabits per second over a coaxial cable and will be introduced in the early 1970's.[19]

(d) Laser and wave-guide systems will permit a considerable increase in capacity.

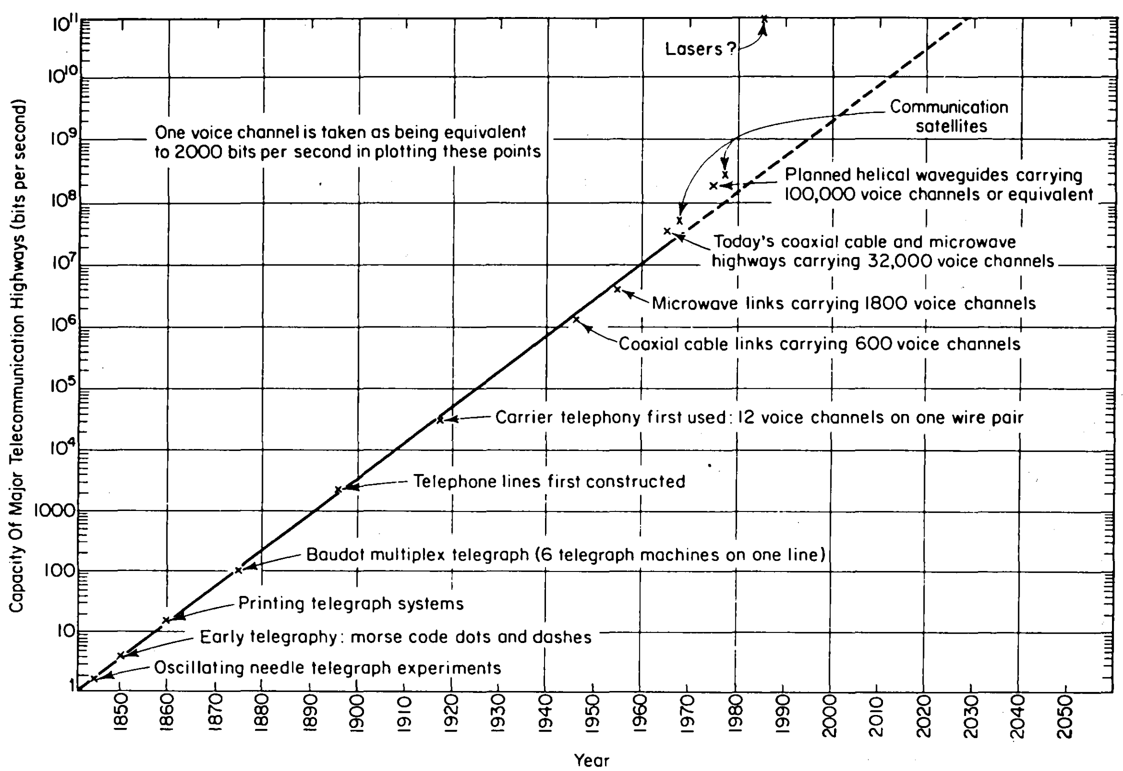
Exhibit 11 illustrates a potential sequence of events in telecommunications progress. In the President's Task Force on Communications Policy it was stated:

> For U.S. Domestic Services, Paired Wire is Likely to be the Dominant Mode on Fixed Capacity Routes of Fewer than 500 Circuits; Microwave Between 500 and 15,000; Coaxial Cable Between 15,000 and 80,000; and Wave Guides Above 80,000.[20]

In addition, the cost trends in terrestrial transmission, as illustrated in that same report, are shown in Exhibit 12. In a study for Datran (The University Computing Corporation subsidiary) by Booz, Allen & Hamilton, there was an estimated increase in data calls by 1980 of approximately an order of magnitude. By contrast, the telephone company is predicting an increase by a factor of two in their calls within ten years.[21] It has been stated that AT&T is making quite an extensive survey of the future data communication market,but no detailed data has been released as far as is known at the present time. Exhibits 13 and 14 give one illustration of the forecasted number of data terminals by type of location and device, and, in addition, illustrate the forecasted call volume by economic segment.

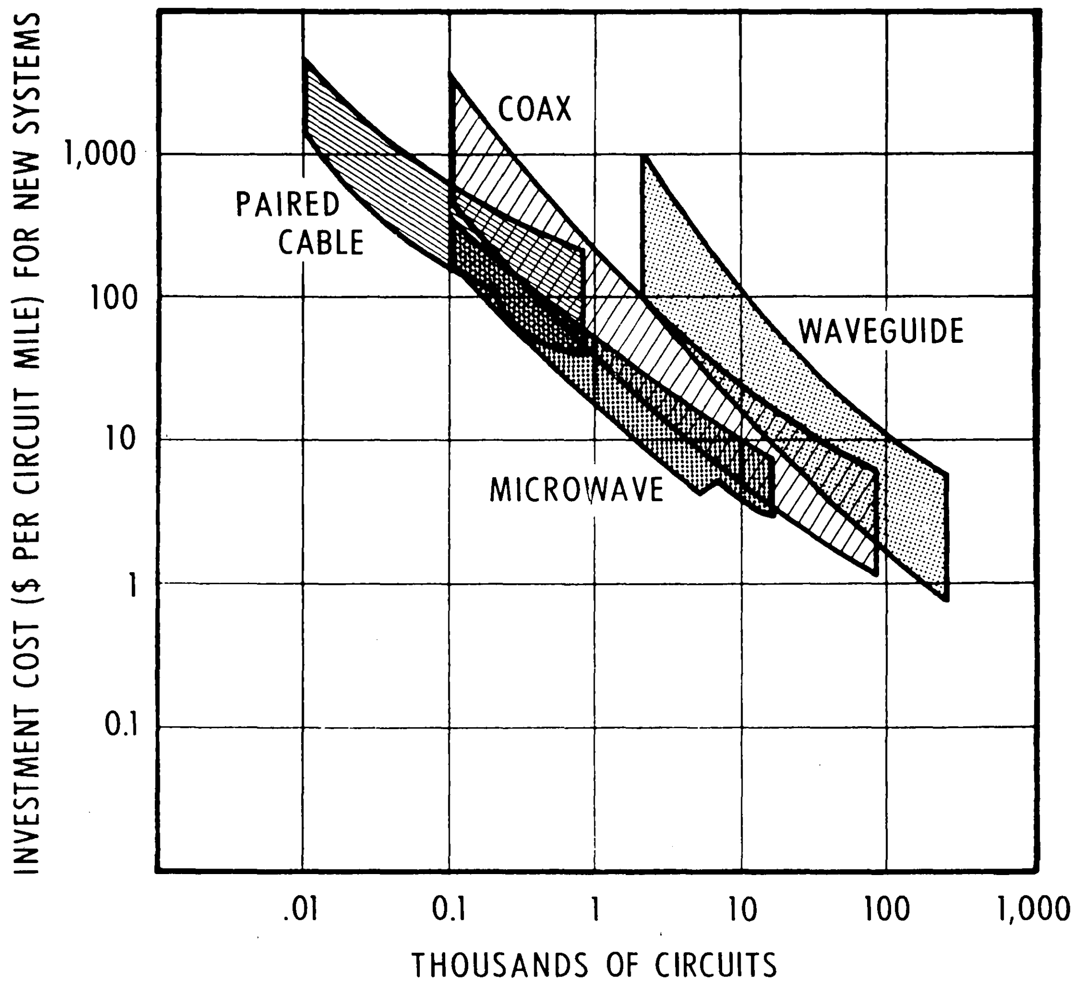
The foregoing information, including projected capabilities and requirements, must all be considered in the light of interaction between policy and technology as well as economics. There are problems

EXHIBIT 11
THE SEQUENCE OF INVENTIONS IN TELECOMMUNICATIONS

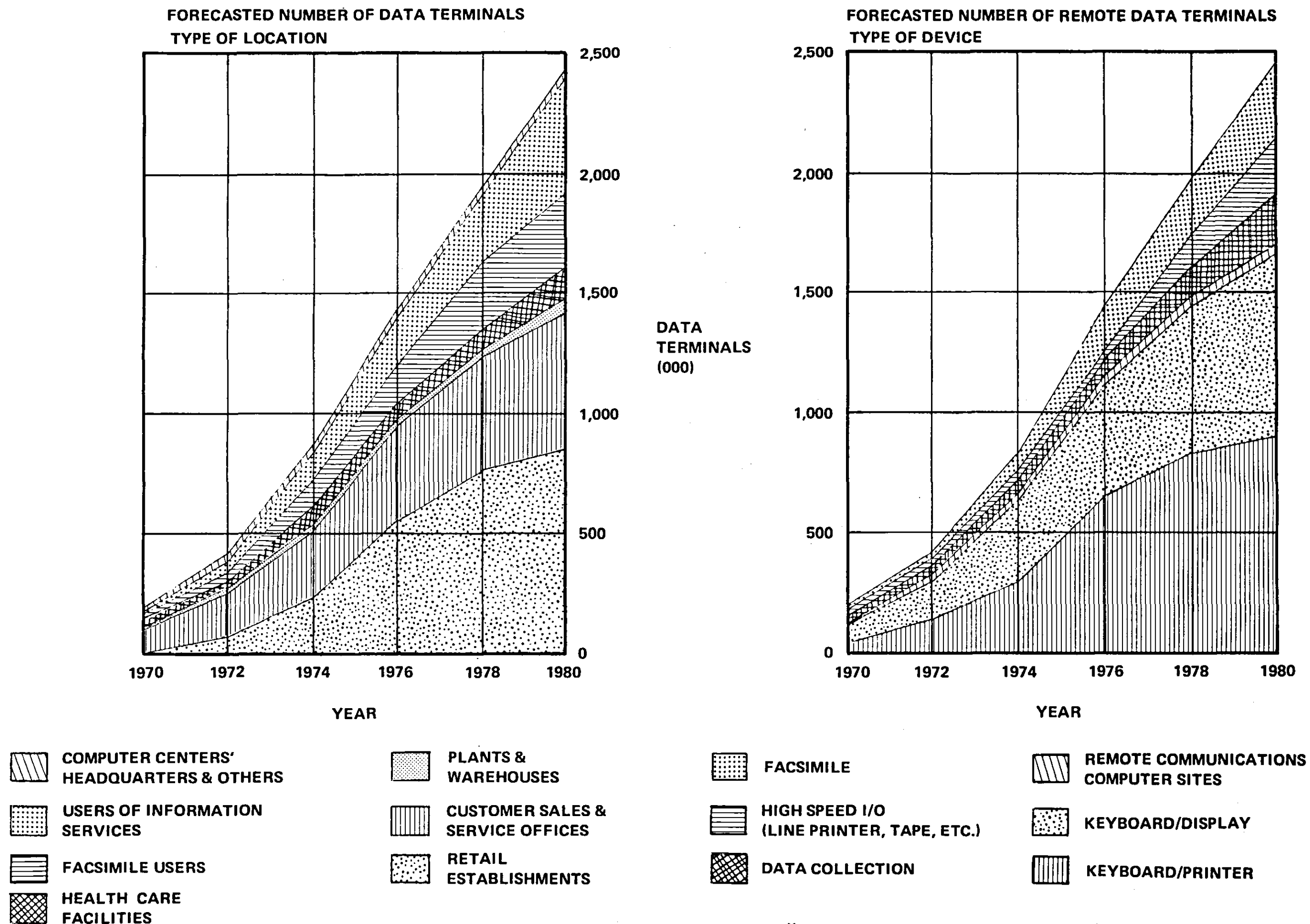


Source: James Martin, Telecommunications and the Computer, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1969, p.8.

EXHIBIT 12
COST TRENDS IN TERRESTRIAL TRANSMISSION

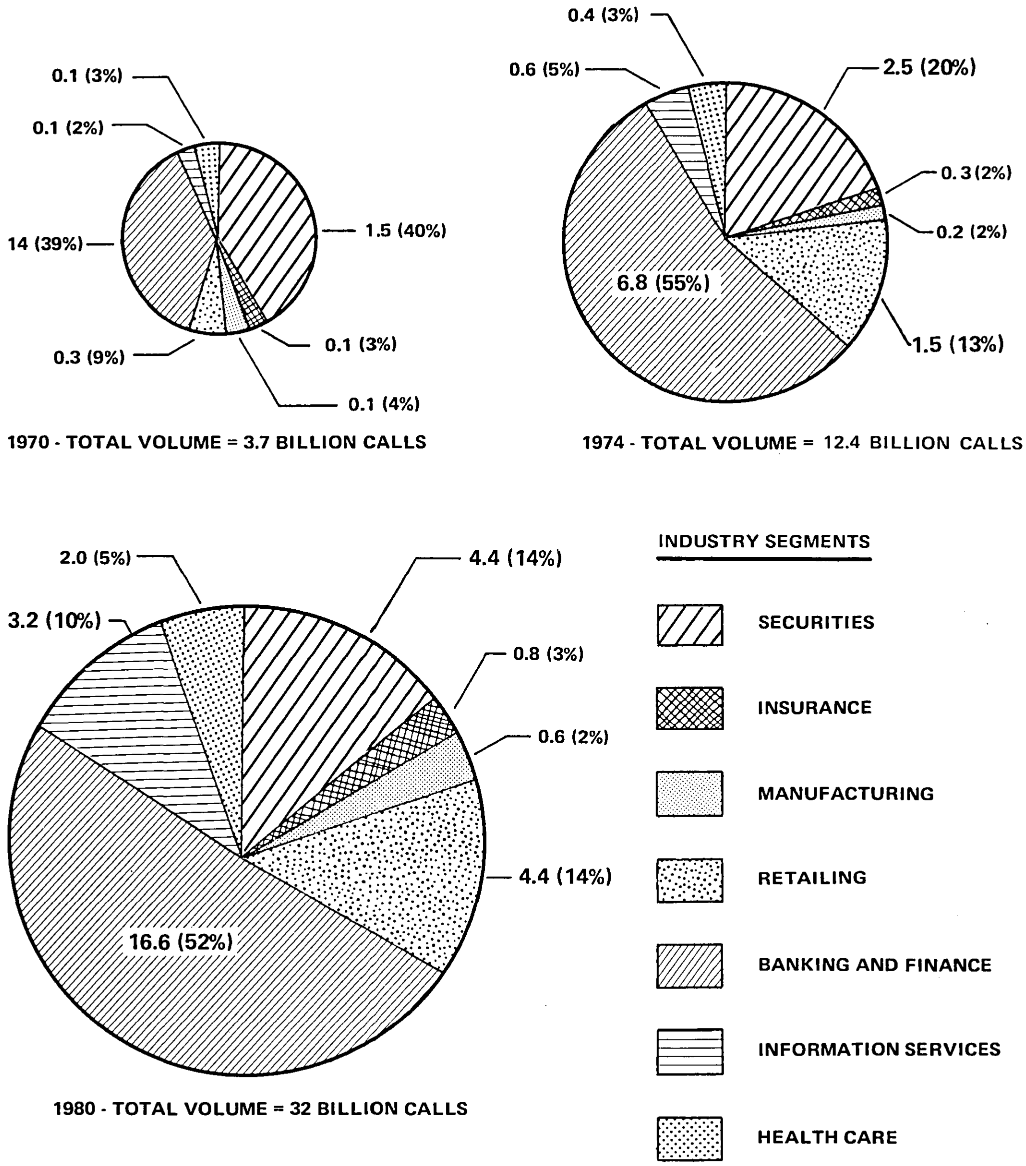


Source: <u>President's Task Force on Communications Policy, Staff Paper I - A Survey of Telecommunications Technology, PB-184-412, June 1969</u>.



Source: Computer Decisions, "Crisis in Data Communications - Some Projections of Growth," p.C7 Nov.1970

EXHIBIT 13
FORECASTED NUMBER OF TERMINALS



Source: Computer Decisions, "Crisis in Data Communications - Some Projections of Growth," p.C7 Nov. 1970

EXHIBIT 14
FORECASTED CALL VOLUME BY ECONOMIC SEGMENT

in the allocation of the electromagnetic spectrum as well as the economics of AT&T versus potential independent and competitive common carrier organizations. Many government organizations may be involved to some considerable extent in shaping the future of this technology over the next decade or more. Finally, it should be noted that "...It may soon become standard practice to install underground broadband cables during the construction of new housing tracts, as in the Columbia, Maryland, development. Large economies would be possible if several cables were installed initially even though they were not used immediately."(22)

Microform, Video (TV), and Facsimile*

Continuous efforts are being made to couple microform technology with computers. This is a marriage of convenience and economy. Notable progress is being made in three areas:

(a) microform for paper printouts by computers using Computer Output Microfilm (COM) equipment

(b) converting printed and highly stylized handwritten text, data and drawings into computer processible form using Computer Input Microfilm (CIM)

(c) using optical, high recording-density films as storage for computerized data banks

Growth in the COM Field

Donnelly(23) reported that COM (Computer Output Microfilm) equipment is currently about five percent of the total microfilm equipment business; by 1977, 45 percent of the total volume

*The source of much of the information in this section is Arthur Teplitz, "Microfilm and Reprography," Annual Review of Information Science and Technology, Carlos Cuadra, ed. William Benton, Publisher, Encyclopedia Britannica, Inc., Chicago, Ill., 1970.

would be for systems connecting the computer to microfilm.

A survey conducted for the National Microfilm Association provided the following forecast of COM units in use:

1968	300 units
1970	1,000 units
1975	12,000 units

The growth rate of COM installations is highly dependent on equipment cost. One study optimistically projected an additional 36,000 units by 1975, should a COM unit become available at under $50,000.

The list of manufacturers and service companies in the COM field is growing at a rapid rate. The figure for 1968 was 24 manufacturers and/or service companies; for 1969, 26 manufacturers and 69 service bureaus.

Advantages of COM

Advantages of COM over conventional printer as a means of presenting and storing human-readable data are:

(a) an order of magnitude improvement in speed of converting machine-readable to human-readable form (10:1 advantage in print time with 18:1 reduction in computer time requirement)

(b) easily transportable and retrievable with mechanical or computer-aided search (a 3:1 advantage in retrieval speed)

(c) reduction in material cost (8:1)

Characteristics of Current COM Hardware

COM hardware can be categorized by application areas as follows:

(a) business - an alphanumeric image printer

(b) scientific - alphanumeric plus plotting capabilities

(c) graphic arts - - higher quality output over the latter two types

COM devices can be operated as stand-alone systems or connected to computer on-line in the same manner as other peripheral units. Recording format can be 105 mm. microfiche or 35 mm. or 16 mm. roll film.

Computer-generated microfilm records are currently produced by cathode ray tube (CRT) systems or electron beam recording systems. In CRT systems, images are first created on a CRT screen in human-readable form, then photographed by microfilm cameras. In the electron beam recording process, computer-stored data (or a digitized image) are used to position and control the movement on an electron beam which writes a latent image directly on dry-silver microfilm.

Future advances will exploit the high resolution and speed of lasers. The Link Division of Singer reported that a laser scanner and recorder can successfully handle 50X reduction, with up to five times the resolution capability of present-day CRT scanners. Another promising recording technique comes from the field of holography (again using lasers). This is particularly suited for storing and reproducing drawings. A picture of an object is first produced by a microfilm plotter; a transparency is made; a laser scanner using the holography principle converts the image into a two-dimensional 'interference' pattern. Individual holograms can be superimposed to form a composite hologram. The composite appears three-dimensional and shows a 360 degree view of the object. Holograms can be readily copied for mass dissemination.

Status of CIM Development

COM converts machine-readable data to human-readable images. The reverse process of transforming documents, forms and pictures into digital form that is storable in a computer (CIM) is less advanced. Such a capability will:

(a) provide a large-capacity, low-cost medium for storing digitized data ready for transmission over data communication lines

(b) by-pass keyboarding of data, when used with a film-optical sensing device

Examples of CIM devices are:

(a) the AMACUS system, which uses a flying-spot scanner to convert drawings on aperture cards to digital form (Subsequently, the digitized image can be displayed on a CRT and modified through keyboard and light pen actions. The updated image may be regenerated onto an aperture card.)

(b) an OCR device that is capable of recognizing alphanumeric characters recorded on a microfilm and encodes these characters for computer processing (A unit has been developed to accept graphic symbols and alphanumeric characters in any style of type, accommodate intermixed fonts and store special patterns identified manually for future reference.)

(c) a Film-Optical Sensing Device for Input to Computer (FOSDIC) being used to read microfilm images of census data sheets which are mark-sense forms (FOSDIC reads the marks and converts them into digital form for further data analysis.)

Optical Mass Memory Development

Attempts to use a microform medium as a low-cost mass memory (in the trillion-bit range) for computers has not met with success. IBM constructed an optical storage unit for the Atomic Energy

Commission in the mid-60's. Only a limited number of similar units were produced and sold to other government agencies. It was subsequently withdrawn from the market. The weaknesses of the system were slow film development speed, unreliable electro-mechanical operations, and the inherent nonerasable nature of the recording medium (silver halide film).

Microform Storage and Retrieval Systems

Thus far, the discussion has placed microfilm devices in a supporting role with respect to computers, i.e., handling its input, output and storage functions. In library applications this role is reversed, with the computer (or other electronic devices) assisting in the location and retrieval of microform material. Typically, microform cards are stored in arrays of storage bins. A moving electro-mechanical arm will reach a specific bin, pull out a single microform, and transfer it to a reading station (e.g., a high resolution Vidicon camera). The address (or identification code) of a microform can be supplied either by a computer or keyboard. Several companies are producing devices of this type: the MIRS (Micro Interactive Retrieval System) by Cytek, the Mosler 410 system by Mosler, the MICROSEARCH 400 by DSI, the Mindex System by Microform Data System, and the Foto-mem 390 System by Foto-mem, Incorporated.

These devices are relatively expensive (several hundred thousand to several million dollars). Until the cost of these devices drops significantly (by a factor of three to five) they are economically feasible only for large organizations.

Impact of Microform on Publishing

The potential of microform in the publishing business has long been recognized, but it has not yet gained wide acceptance among commercial publishers and the general public. On the other hand, the U.S. Government and its agencies are deeply involved in micro-publishing: over 33 million feet of microfilm and in excess of 14 million microfiche were distributed in fiscal 1967.

There are a number of factors that deter the wide-scale use of microform as a substitute for the traditional book form:

(a) A book is portable, requires no additional device to enlarge or convert it to readable format; people can write on it.

(b) Almost the entire body of human knowledge is now stored in book form. They exist in large numbers and are intimately integrated into all human activities.

(c) Elaborate systems have been developed to classify, store and retrieve books or information from books.

The argument for introducing micropublishing is that microforms are light, durable, and easy to store and reproduce. Material cost will be lower (e.g., National Technical Information Services sells hard-copy reports for $3.00 (and up) and microform versions for $.90).

A dramatic impact on publishing that will result from the wide-scale use of microform is the flexibility it offers. Instead of organizaing information in a rigid form and structure for mass circulation, as is done in book form, micropublishing, coupled with computer technology, will make it feasible to extract, compute and package information to meet specific needs on demand.

A Broader Perspective

If individual homes are to have terminals capable of accessing networks of local, regional and national electronic libraries in the 1975 to 1980 time frame, micropublishing and computerized dissemination of information would add a new dimension to communication, affecting all facets of human activity, including commerce, scientific research, and education.[24] Before this materializes, certain socio-economic issues must be settled, such as copyright protection, incentives and improper information control or censorship; and certain technological developments in TV and facsimile equipment must reach the successful field-test stage.

The economic factor is an important one. It takes about six minutes to transmit a typewritten page image over standard telephone lines. If pictures, gray scale/tones, etc., and good (high) resolution is desired, then graphics will take much longer. Transmission cost may be as high as two to three dollars per page as a function of distance. Other potential delivery methods are being explored or are in limited use, including cable television, satellite, radio stations (e.g., FM channels).

Copyright laws will have to be revised. Current laws are difficult to enforce; there is a potential violation each time a copier or a microfilm printer is used. Several proposals have been advanced.[25,26] One recommends that a new form of copyright be added, i.e., charge a licensing fee for reformatting information. Another claims that effective protection should be at the point of input, with input licensing covering output and computer manipulation. It has been pointed out that there are three major related issues: copyright status of CATV, rights dispute between performing artists and recording companies, and exemptions being sought by schools, libraries, and nonprofit organizations.[27]

Technological developments in television and facsimile transmission will help revolutionize the documentation, storage, and dissemination of data, text and graphics. The combination of four technologies, computers, microform, transmission, and terminals, will make it possible to achieve the benefits of man-machine symbiosis, as envisioned by J. C. R. Licklider[28] and others, on a national scale rather than confined to the environments of a laboratory. Important developments in the coming decade will probably include:

(a) low-cost video recorder and playback devices easily attachable to standard TV sets with selective recording and retrieval capabilities

(b) nonelectromechanical, hard-copy reproduction equipment operating in conjunction with a remote terminal with low copying cost

(c) high-resolution TV monitors providing the flexibility of electronic magnification variation and aspect ratio control for a wide variety of optical format microfilms

(d) significant improvement in speed and resolution of facsimile equipment so that scanners and printers may become common office equipment

ALTERNATIVES TO AND WITHIN THE TECHNOLOGY

In certain cases, which are relatively narrow in scope, a particular embryonic, or perhaps even an ongoing, technology can be replaced by another technology. If a specific technology is directly or indirectly causing major problems, replacement is a potential solution. However, a technology as broadly based, far-reaching, and well developed as computers is not really in the replaceable state. A more feasible approach is to provide adequate control for present and projected problem areas. The items below are presented to illustrate the fact that in some cases the only alternatives are not attractive and, in particular, not performing a task at all or performing it in a rather inefficient, costly, and unreliable manner.

This list also includes a few examples of some competition within the computer technology field.

(a) using computers versus not performing the function at all (e.g., computing a sophisticated trajectory for interplanetary travel versus not making the interplanetary trip at all, or the use of computers in highly sophisticated numerical analysis problems in nuclear physics versus not performing the research at all)

(b) possible competition between a terminal to a large central system and stand-alone small computers and/or advanced desk calculators of more recent vintage

(c) competition also with respect to various components of the overall computer-communications system, e.g., various types of memories

(d) possible competition for the transmission of data, especially large quantities of data, e.g., several reels of tape (instead of using the electromagnetic communication system, one might transfer the data by plane, bus, train, and automobile, depending upon the cost and benefits of the particular situation.)

(e) potential competition between general-purpose and special-purpose machines and between analog and digital systems

In summary, the competition for the most part seems to be within the computer field in general, rather than competition between general computer technology and some other area of technology.

Exhibit 15 presents a summary background statement of the computer technology description.

EXHIBIT 15
TECHNOLOGY DESCRIPTION BACKGROUND STATEMENT

MATTERS ADDRESSED	COVERAGE
1. Physical and Functional Description	Computers and communications supported by such scientific disciplines as operations research, systems/policy analysis, mathematics; EDP and communications industries heavily involved; computer professionals, mathematicians, engineers, systems analyst; wide variety of products affected.
2. Current State of the Art	Highly advanced with projected relevant interaction between computers and communications; modeling simulation advanced but needs significant and further research and development and significant data gathering.
3. Influencing Factors	Breakthroughs and directed research required: voice input at least to a limited extent; relatively inexpensive sophisticated terminals/minicomputers, increased software certifiability and verifiability; increased acceptance on the psychological and political level of the most innovative technology; a practical and economically viable solution to the security/privacy problem; performance standards and measures -- hardware and software.
4. Related Technologies	Communications, microform, TV.
5. Future State of the Art	Initial applications, presently operational; and projected applications, operational by the 1980 to 1985 time frame.
6. Uses and Applications	Extremely wide spectrum including decision making/decision maker; policy sciences/analysis and systems analysis; professions, medical, legal, educational.

CHAPTER III

STATE-OF-SOCIETY/UNIVERSE ASSUMPTIONS, ATTRIBUTES, AND CONDITIONS

This chapter illustrates the kinds of conditions and assumptions to be made regarding future circumstances that are likely to have an impact on the application of computer technology. It should be noted that the time frame for this information is the same as described in Chapter I, Task Definition, i.e., 1965 to 1985, with emphasis on 1980 to 1985. A particular societal condition may impede or accelerate the growth of technology and its application, and then in turn itself be impacted by the innovated technology. This can produce a highly dynamic situation through the various feedback loops which occur and modify any initially rather static conditions. Certainly it is not always intuitively obvious what the "steady-state" condition will be.

The computer, its applications, and the computer-based information network have too vast a potential for this limited analysis to investigate exhaustively. The approach, therefore, in this pilot study is to identify some of the major impacting assumptions and conditions. There can, of course, be many more major elements and certainly a much larger expanded list of minor societal conditions and assumptions.

Thus, the approach is to choose a subset of the macroelements and microelements which illustrate the method involved. This subset is chosen so as to be a representative class of major assumptions and/or conditions.

The format for the macropremise is as follows:

(a) identify the major area under consideration, such as economic or institutional

(b) identify the assumptions/conditions of major importance

(c) discuss the relevance to the computer pilot study

(d) identify a potential set of measures as appropriate

MACROLEVEL ASSUMPTIONS AND ATTRIBUTES

National Goals, Policies and Conditions

Centralization of Government

The extent to which national policy promotes federal rather than regional centralization can have a major effect on the type of computer-based information networks developed, since it will present a major policy constraint, or "ground rule," to overall systems design. This will impact upon both the costs of system development and operation, and the benefits derived from such a system. Some of the measures involved would be the amount of information flowing to the major nodes in the network and the number of decision points within the network.

National Transportation Policy

During the 1980 to 1985 time frame, communication/computers can be competitive with the national transportation system, depending on whether or not workers travel to and from their offices or work at home, and whether or not businessmen must travel to attend conferences, or perhaps use an advanced computer-based information communication network.[29] If the national transportation policy sets a high-level floor beneath the transportation industry, it may preclude any major development and implementation of the communication/computer alternatives.

If, on the other hand, national policy fosters open competition, this would present an entirely different situation. Therefore, the assumption regarding the national transportation policy is quite vital. This type of policy assumption is essentially revealed by the presence or absence of a specific policy in legislation and directives of the executive branch. Measures one might consider are total transportation time from source to destination and return, and safety measured in the number of deaths and/or accidents per transportation unit/trip.

Defense vs. Civilian Sector

The assumptions as to the share of resources devoted to defense vs. the civilian sector would have a mixed effect upon impacts of computer technology. If the percentage of resources allocated to the civilian sector continues to increase, then the commercial developments in computer-based information networks should increase rapidly. Conversely, if the defense budget for various reasons increases in percentage of resources, then the civilian information network may move rather slowly, but many advanced developments would be undertaken as part of the defense program. Two measures which would at least illustrate the trend are the following:

(a) the ratio of the percent of the total budget allocated to defense vs. that allocated to the public sector

(b) the ratio of the percentage change in defense budget vs. the percentage change in the public sector budget over the next decade

National Health Policy

Since one of the major applications of the computer-based information networks is their potential use in medicine, the assumption relating to national health policy can easily dominate the situation. An example of this might be called "reverence for life and health" when applied to the following type of problem: if, through the use of advanced computer technology, one is able to treat more patients and extend their lives, then it might be shown that as a first-order effect, there would be a financial gain to society. But some might argue that, first, this contributes to the overpopulation problem, and that, second, if this advanced technology assists in extending the lives of the aged, there will be an additional financial burden on society. This is actually a general problem in national health policy and is not limited to advanced computer network assistance. It will be the assumption for this study that our national health policy will definitely include "reverence for life and health." Thus, even if additional resources must be spent caring for individuals whose lives have been saved and prolonged through the assistance of advanced computer technology, the extension of life and better health will definitely be considered a benefit, gain, or desirable goal. For a further discussion of this issue see Joshua Lederberg's article on technology assessment.[30]

Other principal issues are what kind of legislation will likely be enacted and what impact such legislation will have upon the health situation. Some of the measures for this area are the number of medical schools, their expansion and training programs, and the hospital expansion program.

Public Order and Justice

The problem of crime, the nation's court case load, and the general administration of the nation's legal system will have a major impact on the requirements for the use of advanced computer technology. Some measures that might be considered are the number of crimes committed and the total number of both criminal and civil court cases. In addition, the rate of change and total number of new statutes created are potential measures of these societal conditions.

Education and Training

The projected level of education of the average citizen and the amount of training and retraining necessary throughout the citizen's career will have a major influence on computer-based information technology applied to this area. If it is assumed that the nation will have either education through junior college or college levels, or massive training programs for adults, impetus will be created for advanced computer development in this area. Some of the measures that one might consider are the amount and type of legislation passed, the number and types of individuals who must be educated and trained, and the percentage of education that can be performed within the home through the use of a terminal. Another measure would be the projected number of schools using computers for direct student interaction.

Communications

The communications area is of major relevance to both the projected policy and the technology. The types of projections and/or assumptions one makes about future government policy and tariffs for the time frame under consideration will play a dominant role in the development and application of computer-based information networks. Some of the measures in this area would be the actual policy conditions laid down by the FCC and such characteristics of the nation's communication system as extensive use of domestic communication satellites and laser communication facilities.

Citizen Values (Individual, Group, and Societal)

The Acceptance of Technological Change

The acceptance by individuals and groups (and even society in general) of technological change will tend to dominate the implementation of the new computer technology under consideration. If one assumes psychological inertia against these innovations, then the rate of implementation and the rate of economic success for entrepreneurs will level off in the near future in the public market place. Should citizen acceptance grow at a fast rate, additional entrepreneurs would enter the competition and the entire development would be accelerated. The set of measures would include the number of new businesses presenting on-line computer access services over the next decade, the gross revenues and the amount of profit for these new businesses.

Opportunity vs. Security

An important assumption will be the general outlook of society and its members on the issue of the potential opportunities of economic, social and political advancement through the use of advanced computer-based technology vs. any tendency to stay with minimal technological advances in order that threats, real or imagined, with respect to privacy/security, automation, etc., be avoided.

Gross Economic Consideration

The overall economic situation for the next ten to fifteen years would affect the developmental projections for advanced computer technology in the following manner:

(a) If there is an extended depression or a series of recessions, then the overall development will be at a minimal rate.

(b) If, on the other hand, there is a continually expanding economy, with one or two relatively short-duration recessions, the development and implementation will proceed at a rapid pace. Some of the measures of these conditions include the change in GNP and GNP per capita and unemployment rates. The overall situation is pertinent, rather than any one of these measures or conditions in particular.

Time-utilization Patterns

The work/recreation/education-training patterns of the nation will impact upon computer-based information networks at least in terms of time available for the use of training, advanced education or retraining aided by on-line terminals. This is, of course, one of the interactions, since advanced computer systems can contribute to the shortened work week. Measures of this condition would be the length of the work week, e.g., 20 to 30 hours, rather than the present 40 hours, and the number of hours projected at the terminal for individuals.

Income Distribution

The assumed personal income will indicate whether individuals have the necessary financial resources to obtain and maintain computer terminals. This can be measured in per capita take-home pay.

International Competitive Balance

The assumption or projection regarding technological balance of trade is quite important since indirectly advanced computer systems can assist in making industry more productive. Secondly, computer systems constitute one of the technology-intensive areas in which this country enjoys a favorable balance of trade.

Institutional, Political and Legal Factors

The War vs. Peace Situation

The issue of war and peace will obviously have major impacts upon computer-based information networks. Projected situations are as follows:

(a) If there is an all-out nuclear war, such a catastrophe would totally dominate the entire analysis.

(b) If there are conventional wars, the results may be mixed. Major resources would probably be siphoned from the public sector to the defense sector; thus the growth rate of computer technology application may slow down. However, some major advance in computer-based information networks can also result from military applications.

(c) Peace, with perhaps international competition in a broad sense, would be conducive to steady growth in the development of advanced technology in both the public and private sectors.

Consumer Protection/Representation

If increasing emphasis is given to the protection of consumer interest, then this should impact heavily on computer networks and data banks, and would be a major consideration in part of the computer privacy problem. A measure in this area might be the number of legal actions initiated and won by consumer representatives.

Legal Aspects

At the end of the 1960's, as the use of computers expanded, a growing number of users found that computer systems fell short of their expectations; in some instances system errors seriously disrupted business operations. Damage suits were filed against manufacturers and software suppliers at increasing frequency. According to an article in The Wall Street Journal, for November 30, 1970, lawyers expect more suits to be brought in the future partly because the public is becoming less tolerant of computer errors. In one, the plaintiff asked for $70 million in damages.(31) With the introduction of computer networks, the adverse effects of system errors may impact on not one, but several users. Errors in a retailer's data base, for example, can propagate into a supplier's and disrupt both companies' business. In a situation where a computer system is integrated into the management decision-making process in a company, erroneous data could lead to wrong decisions, the results of which would be fed back to the computer and become the basis for making new decisions. Once an error is introduced into such an integrated system, a chain reaction will be started gradually degrading the accuracy of the systems data base and creating chaos for a company.

Problems of performance specifications, prediction and measurement and techniques for controlling data base integrity will, therefore, receive a great deal of attention in the next decade as the survival of firms and large financial stakes are involved.

Demographic Factors

The population total will have an impact both from the point of view of economics, the needs and requirements of the citizen and a potentially larger tax base. The projected distribution of the population among urban, suburban, and rural areas should have a major impact upon the computer communications vs. transportation analysis. Some measures for this area are both total population and its distribution by geopolitical area.

MICROLEVEL PROJECTIONS, ATTRIBUTES, AND ASSUMPTIONS

Microelements are found to overlap with macroelements. Some of the microlevel elements are details for potential measures for the previously described macrolevel projections, attributes, and assumptions. The checklist of microlevel elements is presented here to make the methodology complete.

(a) number of computers present and projected--Exhibit 16 illustrates a computer population survey

(b) number of terminals present and projected--Exhibit 17 illustrates a projection of number of terminals

(c) communications capabilities present and projected

(d) government policy and tariffs for the time frame under consideration

(e) amount of information and data generated by source data automation, R & D publications and information generated for management

(f) the court caseload

(g) medical school expansion and training

(h) hospital expansion

(i) advances in modeling and simulation and their acceptance in the higher echelon of decision making

(j) numbers of schools using computers for direct student interaction

(k) amount of capital available for development of management control information centers

(l) amount of capital available for innovative enterprises such as large time sharing centers and regional or national networks

(m) development of legal theory with respect to computers in particular privacy and software copyright

(n) development of domestic communication satellites

(o) development of competitive microwave communications systems

(p) development of standards for preparing, processing and reporting various kinds of statistical information

(q) development of general standards for the computer-communications field.

EXHIBIT 16
PRESENT WORLD COMPUTER POPULATION

U.S.	62,500
Western Europe	24,000
U.S.S.R	5,500
Eastern Europe	1,500
Other	12,500
World Total	106,000

West Germany	6,100
United Kingdom	5,900
Japan	5,900
France	4,500
Canada	3,000
Italy	2,700
Scandinavia	1,500
Netherlands	1,100

U.S.S.R.	5,500
East Germany	500
Poland	420
Czechoslovakia	200
Yugoslavia	180
Hungary	120
Romania	50
Bulgaria	30
	7,000

"PRESENT WORLD COMPUTER POPULATION (table at left) combines the author's estimates for eastern Europe and the U.S.S.R. with figures compiled by the International Data Corporation for the rest of the world as of January, 1970. Of the 62,500 computers shown for the U.S., some 46,500 are general-purpose machines, the remainder being "dedicated," or special-purpose, units. For other countries the figures represent chiefly general-purpose computers. The middle table, also based on figures from International Data, lists the top eight computer users aside from the U.S. and the U.S.S.R. The table at the right is the author's estimate of the number of computers in individual eastern European countries. According to the author, 60 to 80 percent of the computers in western Europe and the U.S. belong to the "third," or latest, generation, with the remainder being of the second generation. In eastern Europe and the U.S.S.R. fewer than 5 percent are the latest models whereas some 35 to 38 percent are still first-generation machines."

EXHIBIT 17
PROJECTIONS OF COCI AND TERMINALS

"These revenues to common carriers from COCI would derive in large part from communications between computers and terminals (as opposed to computer-to-computer communication). In 1966 there were 70,000 to 90,000 such terminals, served by 2,500 computer systems. By 1980, these COCI systems are expected to grow to 50-75 thousand, with most being linked to 10-30 terminals. Based on an average of 20 terminals per installation, between 1 and 1.5 million terminals would be in use in 1980."

(COCI - Communications-Oriented Computer Installations)

Source: The GE Submission to the FCC in February 1969, regarding the matter of the establishment of domestic noncommon-carrier-communication satellite facilities by nongovernmental entities.

CHAPTER IV

RELEVANT IMPACT AREAS

The information in this chapter identifies a representative set of the major impact areas. The computer field has a huge variety of applications, as seen in Appendix II, A Sample Catalog of Computer Applications, and in recent magazine advertisements. These advertisements describe a collection of computer programs--more than 3,000 at last count--with approximately 300 different programs for statistical analysis alone, 174 for operations research, 89 general-business programs for billing, payroll, sales analysis and the like.(32) Part B of Appendix II is taken from a list of over 2,000 kinds of applications of computers that was published in the Computer Directory and Buyer's Guide issue of Computers and Automation, November 30, 1970. Even when the computer field is limited in scope to some of those applications which are of interest to the user who is not a professional computer programmer, and, limited to the computer-based information processing system network, it still has an enormous variety of impacts. This can be seen from an examination of Appendix III, Data Base of Forecasts Pertaining to Development of Computer Technology: Present--Year 2000; Exhibit 19, Representative Table of Projected Impacts from Chapter V; and the various projections, statements, and speculations by a variety of individuals, as indicated in this report. This suggests that the technology area chosen for the study (although at present only an embryonic subset of the entire area of computer technology) will be one of the dominant areas of the computer field during the late 1970's and early 1980's.

An example of a current research project which is applying digital computers to several areas in the behavioral sciences, including economics, political science, psychology, and others is

Project Cambridge. The following quotation presents a brief summary of the nature and purpose of the project.

> The purpose of the Cambridge Project is to make digital computers more useful in the behavioral sciences.
>
> For that purpose, the behavioral sciences are defined not by their subject matter but by the methodological problems they share; they are a group of sciences in which the potential uses of computers seem to have enough in common so that they should be considered together. At one extreme, parts of history are included--demographic history, for example--and at the other, parts of neurophysiology. Between them are at least some parts of all the sciences that are often called behavioral: sociology, cultural anthropology, political science, economics, and all the branches of psychology--experimental, social, developmental, and so forth. Some aspects of the behavior of organizations as it is studied in schools of management and business administration are included too. Even that list is not necessarily exhaustive; there may well be other disciplines in which the potential uses of computers are similar enough so that they should be included.
>
> The Cambridge Project is a cooperative effort to further the progress and application of those sciences by devising better ways of applying the power of the digital computer to them. It is a cooperative effort in two senses: the participants come from a number of fields--computer science, statistics, and a variety of behavioral sciences--and they come from two universities, M.I.T. and Harvard. All in all, about 45 faculty members and about 130 students and research personnel are taking part.[33]

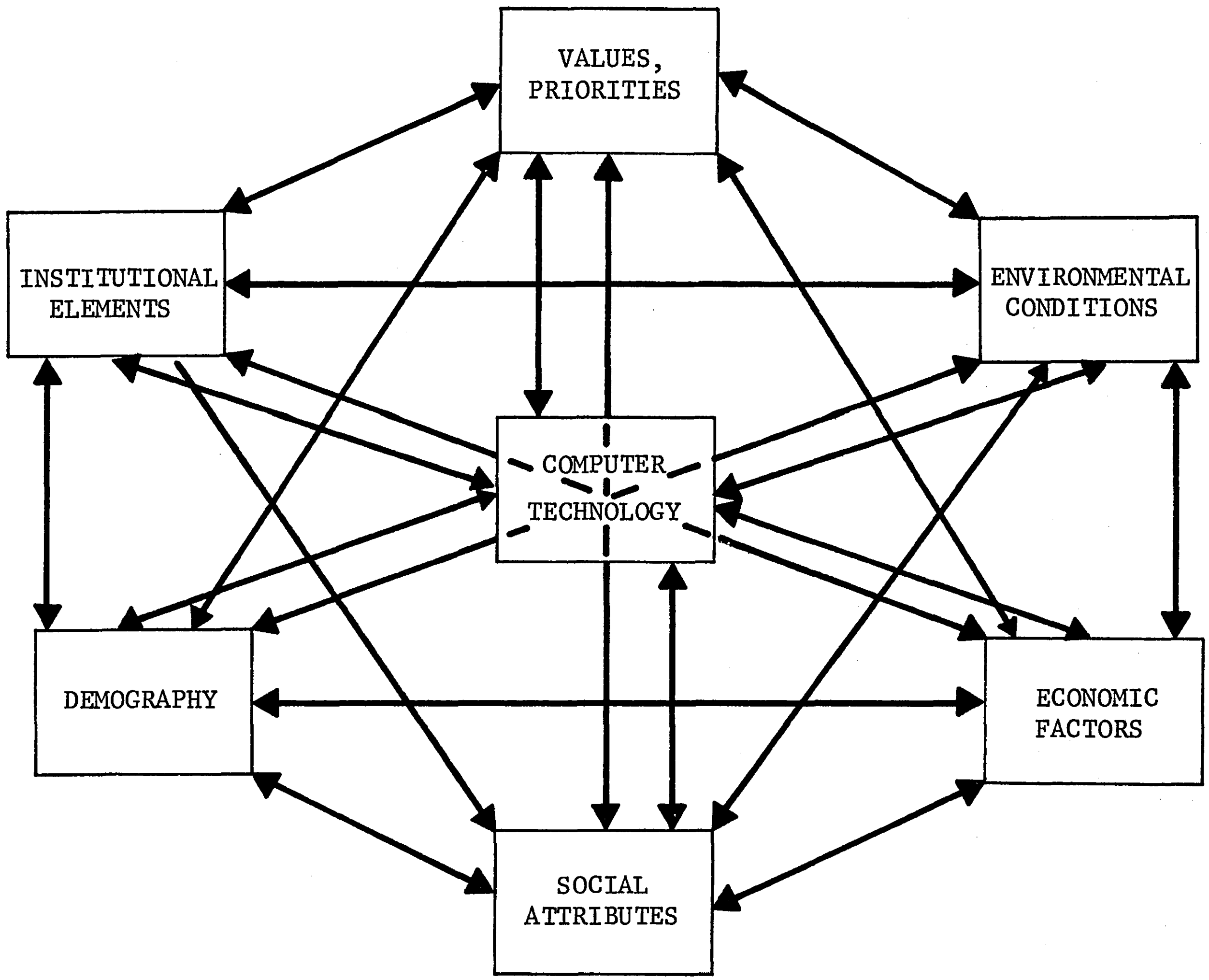
Chapter III, State-of-Society/Universe Assumptions, Attributes and Conditions and this chapter, Relevant Impact Areas, should in many ways be thought of as describing an interacting feedback system. Some of the impacts of the computer technology will probably change the conditions of our society, as well as the societal constraints accelerating or impeding progress in these computer applications. For example, if the computer communications technology improves the performance-per-resources-expended in the delivery of health care, then it would be appropriate to make cost/benefits analyses regarding such application of the technology. Results of the analyses could then guide decision making pertaining to our national health policy and could very well lead to increased use of computers in the medical field. It should be noted that some of the impacts may be secondary or tertiary in sequence of events over time but that, nonetheless, some of the later impacts may very well be of primary or major importance. We, therefore, have a situation that includes cross impacts, e.g., the impact of economic changes upon societal conditions, followed by higher order and delayed major impacts; taken together they describe the interaction between technological impacts and societal conditions. This can lead to a highly complex and dynamic situation which would indicate perhaps the need for a simulation model à la Forrester's, Urban Dynamics, and perhaps other models. This is discussed in the following chapters.

Exhibit 18 presents an illustration of the interactive nature of computer technology impact analysis.

The approach in this pilot study is to identify a representative set of some of the major impact areas. All of the elements discussed herein are considered major impacts. The general time frame considered is again approximately 1965 to 1985 with the emphasis on the latter 1970's and the 1980 to 1985 period. Certainly there can be many more major elements and a much longer list of minor impacts than are presented in this chapter.

A subset of the macroelements and microelements has been chosen to illustrate the method involved. This subset is representative of major impact areas and elements. The procedure for the macroimpact areas is as follows:

EXHIBIT 18
THE INTERACTIVE NATURE OF COMPUTER TECHNOLOGY IMPACT ANALYSIS



(a) identify the major area under consideration, such as societal or economic

(b) identify the major impact of computer-communications technologies

(c) identify a potential set of measures as appropriate (It is considered more relevant to present a discussion with some potential measures rather than just a listing because the relevance, especially with respect to methodology, can be made clearer in a discussion and it usually takes a set of measures rather than just a single measure to adequately describe and/or quantify the relevant impacts.)

MACROLEVEL IMPACTS

Planning and Policy Formulation: Values, Goals, Priorities

The extent to which national policy and major decision making utilize a computer-based information processing network will be an indication of the extent of the computer-communications technology impact. This includes data gathering, establishment of data banks and presentation of the results of analysis of this data, as well as the presentation of models and simulation to the decision makers and their staffs. The models and simulations can be used to assist in the formulation of policies which are developed to achieve national goals, for example, in the health or housing fields. Then a modern computer-communications information system would gather data on the implementation and results of this policy. The analyzed data would then be compared with program objectives and a process of iterations and modifications would continue. This would exemplify the utilization of an information feedback system to help shape society and the environment in accordance with established goals.

Some of the measures for evaluating the impact of the technology would be the number of policies which could be examined (perhaps in simulation form), and the amount of data that would become available to validate and substantiate program benefit and cost claims.

Environment

A computer-communications-based information system including monitoring, data collection, and analysis would potentially have a major impact upon the quality of our environment. Large computer models of the weather system would greatly improve long-range and large-scale weather prediction. The monitoring and analysis of air and water pollution should result in a better understanding and forecasting of these major problems. An illustration of what might be accomplished can be seen from the following:

> In the major cities of Japan environmental disruption caused by air pollution have become serious. Especially in such large cities as Tokyo, Osaka, etc., it has become one of the most serious problems which should be immediately solved. The Osaka prefectural government has installed the collective surveillance system equipped with telemetering network for the rapid assessment of air pollution and weather conditions, and for controlling major pollutant sources.
>
> Only this installation, however, does not suffice for prevention of air pollution. This project has been initiated to provide a theoretical base for the air pollution control policy to execute the adequate activities by forecasting pollutant concentration through electronic computer system.[34]

In the United States, programs of the Federal Government directed toward abatement of the air pollution problem are under the cognizance of the Air Pollution Control Office of the

Environmental Protection Agency (formerly the National Air Pollution Control Administration (NAPCA) of the Department of Health, Education and Welfare). The need for support from a computer-communications based information system has been well established. The following is quoted from a recent study performed for NAPCA:

> The objectives of a new NAPCA data processing system are to meet large and growing requirements for automatic data processing (ADP) capabilities essential to perform functions related to the achievement of the NAPCA missions. These missions include defining and measuring air quality, defining the effects of pollutants, controlling motor vehicle and stationary pollutant sources, and control program operation and administration. The system requirements include sorting large files in a highly structured fashion and providing for their manipulation in a user-oriented language, accurate handling of computational problems, rapid turn-around time, and time-sharing and teleprocessing capabilities. The principal applications will be as follows:
>
> - Conduct ecological, surveillance and effects studies,
> - Gather, store, and retrieve air quality and emission data,
> - Conduct and analyze results of motor vehicle emission tests,
> - Perform grants administration and control,
> - Conduct air quality and implementation planning studies and provide fuel additives registration,
> - Provide bibliographic and administrative support services,
> - Support process control studies,
> - Analyze motor vehicle combustion processes and photochemical reactions, and
> - Perform meteorological support studies.
>
> These requirements attest to the need for a large centralized ADP system providing rapid access to users for scientific and data retrieval applications.[35]

The impact of computer technology would be measured by the alleviation of the pollution problem as indicated by the amount of harmful contaminants remaining after action based upon the computer-communications system has been implemented. This would be a comparison with what might have been expected without such a monitoring, computing, analysis and action system.

Finally, another indication of the impact of computers on the environment is illustrated by the following quoted article which discusses the plan of The World Health Organization (WHO) for an international air pollution detection and warning system.

> The World Health Organization (WHO) has worked for 15 years to get international approval of an air pollution detection and warning system. The go-ahead finally came in May 1970 at the 23rd World Health Assembly. Working with the health specialists are experts at the World Meteorological Organization (WMO) -- which, like WHO, is a specialized agency of the United Nations. The WMO, concentrating on what are considered still unpolluted areas of the world, will keep track of what is termed "background pollution."
>
> WHO's task is to collect and analyze data on real pollution in the cities and other populated areas and to issue warnings whenever necessary. The system selected is similar to WHO's influenza warning program.
>
> The air pollution system is based on: two international centers, in London and Washington; three regional centers, in Moscow, Nagpur and Tokyo; and 20 Laboratories situated in strategic points around the globe.
>
> WHO's computer will receive world-wide data on air pollution levels caused by the six major pollutants selected last October by 30 International experts. These are: (1) sulphur dioxide; (2) particles such as dust, soot, etc.; (3) carbon monoxide; (4) oxidants (which result from reactions induced by sunlight on automobile exhaust); (5) nitrogen oxides (also emitted by motor

vehicle exhaust and central heating systems); and, (6) lead, a highly toxic product added to motor fuel to prevent "knocking."

WHO's computer will compare reported levels of these pollutants to the danger levels programmed into it by health experts and sound the alarm where necessary.[36]

Demography

The projected computer-communications system could have a major impact on the population density distribution during the 1980 to 1985 time frame. This would be a function of the degree to which such a computer-communications system would replace transportation systems. There would also be a projected impact on the death rate because of improved performance of the health system as supported by the projected computer technology.

These impacts could at least in part be measured by increased longevity (average lifespan) and distance between residences and the center of a metropolitan area or location of employment.

Economic

Computer technology should exert a very strong economic impact. Some of the projections and speculations are contained in this document in Chapter I, Technological Scope Narrowing; Chapter II, Complementary Technology; and Chapter V, Exhibit 19, Representative Table of Projected Impacts.

Further indication of economic impact is revealed by a projection made by J. G. Maisonrouge, President of IBM World Trade Corporation, New York City.[37] He predicted that the computer industry will outgross the automobile and petroleum industries and that by the year 2000 data processing will stand as the world's largest industry.

The following quotation gives another indication of economic impact:

> Speaking at a symposium on technology and international trade conducted by the National Academy of Engineering, Maisonrouge added, "Its annual revenues are already impressive. In the United States alone, total annual computer revenues -- which include income from hardware, software, related services and supplies -- grew almost 1,100 percent over the last decade from $975 million to $10.6 billion in 1969."(38)

With respect to the international competitive balance and the technological balance of trade, the following quotation from Maisonrouge presents an indication of the situation:

> When you further consider that the marketplace for computers outside the United States is growing at the rate of 25 percent annually in value of equipment in use and the foreign markets will account for almost 40 percent of the shipments by U.S.-based manufacturers this year, you get some feeling for the impact and potential of computers in international trade.(39)

Another indication of the impact of computers upon U.S. exports is illustrated by the following quotation.

> The basic reason is that in 1969, Commerce Department officials decided computers, peripherals, and software comprise one of six product areas having the greatest potential for increasing U.S. foreign trade. That decision led to a voluminous survey of the market for U. S. hardware and software in 25 countries. The study, released in September, predicted that total U. S. hardware exports should reach $1 billion in 1970, and $2 billion in 1974, excluding shipments by U. S. subsidiaries and licensees abroad.(40)*

On the other hand, increased use of computers by other countries may bring about greater efficiencies in their economic systems, and they therefore may become more competitive with the U. S. for world markets for various export commodities.

Finally, a potential major problem area is the requirement for worker retraining caused by computers/automation. This impact will probably become major towards the end of the time frame under consideration, i.e., during the 1980's.

Some of the measures of economic impacts are the following:

(a) GNP--absolute and per capita

(b) time-utilization patterns--allocation of time to work, recreation, and education, especially the decrease in both percent and absolute amount devoted to work and the increase in recreation and education

(c) percentage of work force requiring retraining

(d) income distribution--per capita income

(e) the international balance of trade in the computer area

Societal

The societal impacts of the projected computer-communication network are so broad that only a relatively small representative sample can be mentioned. Chapters V and VI of this document should be considered almost simultaneously with this chapter in order that the picture with respect to computer impacts be made clearer. Societal impacts would include at least the following subareas or elements: national security, economic growth, environment, health, education, transportation, and safety (e.g., crime). Some of the measures of these impacts are contained in the next section of this chapter.

Institutional

The institutional impacts include at least the following categories: political, legal, administrative, and organizational. One of the major institutional impacts as well as societal impact is the problem of security/privacy in an age permeated by computer-based information handling and data bank networks. This presents serious legal difficulties as discussed in Chapters V and VI. On the other hand, the computer technology should greatly assist in the administration of justice, the apprehension of criminals, and the streamlining of our governmental organizations, such as the Congress.

It should be noted that there will probably be a major impact on the manner in which political campaigns are organized and implemented and potentially with respect to the actual voting structure and procedure. Along with potential benefits of this impact there are problems, e.g., potential cheating in the voting procedure and vote count. This is further discussed in the following chapters.

Some of the relevant measures are contained in the following section.

MICROLEVEL IMPACTS

Microlevel impacts provide a means for developing cost/benefit analyses relative to the macrolevel impacts. Sets of microlevel impacts quantify the broader impacts. The data collected in each of the microlevel impact areas can be used to measure the magnitude of the macrolevel impacts and thus permit associating dollar values and/or specific benefits with the broad impacts.

The following checklist includes only a sample of microlevel impacts; a more comprehensive list would have to be compiled as part of a full-scale assessment of computer technology.

(a) volume of sales in computers and communications (41)

(b) the potential percent of the major common carrier (AT&T) future network capacity utilized in computer-based information systems

(c) number of patients adequately cared for per medical doctor or per dollar spent on medical care

(d) level of education of children for any specified age level

(e) number of adults re-educated per dollar spent

(f) number of cases handled in the court system per unit time and total resources expended

(g) the dollar volume or other measure of transportation between residence and office

(h) changed role of middle manager

(i) balance of political power between individuals and small organizations versus large political organizations

(j) number of patients per hospital resources

(k) acceleration of research and development and the spread of technological innovation

(l) amount of information contained and distributed per library resource expended

(m) the amount of information on any individual or groups of individuals both collected and disseminated in an economical manner

(n) the amount of proprietary, classified, or confidential information released in any unauthorized manner

(o) the number of criminals apprehended and convicted

(p) percent and amount in reduction of labor force or radical change in customary division of time devoted to labor and to recreation (e.g., 10-hour work week)

(q) sabotage and industrial espionage

(r) the complexity and the number of alternative policies and their implementations which are adequately investigated and communicated to the proper decision makers

(s) the quantity and quality of technological assessment studies performed and recommendations implemented

(t) the number of manufacturers of equipment and the number of service, support and programming companies [42]

CHAPTER V

INITIAL IMPACT ANALYSIS

The following discussion is presented as part of the methodology development. The initial plan was for Chapters V and VI to be devoted to an initial impact forecast; action, or control options; and final impact forecast. However, during the early research and analysis performed for this study, it was realized that, although there are many individual impact forecasts for the technology, it would be quite presumptuous to state some of these predictions and speculations, and then proceed to use them as the basis for positive sounding or definitive statements about the future, including a final impact forecast. This lesson was learned through the analysis of the literature, and through interaction and discussions with reviewers. In addition, it is concluded that there is a need for a system of models which include dynamic feedback interactions and perhaps some of the higher order impacts as well. Therefore, Chapter VI includes a rationale showing the logical requirements for a research, development, and monitoring program, as well as a discussion of such a program and the elements of a preliminary plan. Chapter VI also describes the potential evaluation and reevaluation of the research, development, and monitoring program and its interaction with policy analysis and decision making.

The rest of this chapter is, therefore, devoted to:

(a) a statement of projected impacts as developed from the literature research and references and comments as appropriate

(b) an expanded statement of one of the special problems of computer-based information processing networks, namely, the security/privacy problem.

PROJECTED IMPACTS FROM THE LITERATURE RESEARCH

The Representative Table of Projected Impacts, Exhibit 19, includes 70 items from a dozen separate sources, which are listed at the end of the table. These items were obtained from the literature during the research and analysis for initial impacts. One could gather an even larger list, if appropriate, but this table illustrates both potential benefits and problems. Sufficient evidence from this preliminary analysis and judgments is presented to warrant the conclusion that a plan for organizing action options including a research, development and monitoring program and legislative and educational programs should be devised at the earliest time feasible. On the other hand, there is not enough coordinated specific detailed information to produce an entire program plan and, therefore, this information serves as a point of departure rather than any sophisticated analysis. The table illustrates the following points:

(a) Many of the projected events have several major impacts, some of which will occur simultaneously and others which will occur in a time-phased sequence. In fact, the list of impact areas is not exhaustive and simply illustrates a representative sample.

(b) These impacts cut across, essentially, all major areas including economic, social, quality-of-life, goals and values, institutional, political,and societal.

(c) The user/application categories of education, medicine law/administration of justice, decision making/ management, policy/systems analysis, are illustrated as major relevant impact classes. In addition, the average citizen class is included explicitly in a number of the specific cases and implicitly in many others. One or more of these classes are referenced in most of the items.

(d) Several of the items present evidence relevant to the security/privacy issue.

(e) The statements made under the column "Representative List of Projected Impacts from the Literature," are essentially the ideas or concepts contained in the referenced material, although sometimes the exact words may be modified or condensed for the sake of brevity. The reader is invited to consult the specific references for a more complete understanding of the statements within their total context.

(f) Some projections are made on the basis of fairly substantial studies; others are probably top of the head "guesstimates;" some are speculations. Two modified DELPHI studies contribute a significant share of the items.

(g) Item 5 from the table indicates that the automatic control of automobiles by computers will probably not have widespread use until a time-frame beyond that given major consideration for this study.

(h) Items 9 and 11 from the table indicate that the unemployment problem caused by computers and automation may become quite serious, but probably not until late in the time-frame under consideration for this pilot study.

(i) Item 28 is possibly too optimistic, at least if this is referring to widespread use around the world rather than demonstration or prototype systems.

(j) The format used in Exhibit 19 for these projected impacts is: first, a statement of the projection from the literature, second, identification of the source, third, the time frame, and fourth, the type of impact(s) or at least primary impact(s), i.e., economic, social, etc. Not all of the items have a specific time frame explicitly stated but of those that do, almost all are within the time-frame of the present to 1985.

(k) The following quotation illustrates an appropriate perspective, not only for the projected impacts from the quoted document, but also a relevant point of departure for some of the discussions and analysis of this document.

> This paper reviews in a nontechnical fashion the principal technological developments that underlie the communication revolution, especially the transistor and the computer. A number of devices and communication subsystems that make use of these developments are then described, together with the new capabilities that they permit.
>
> The main body of the paper discusses some possible social consequences of the communication revolution and indicates some of the policy questions they raise. In some cases changes are shown to be already underway. Social effects are discussed in the fields of education, political behavior, crime, economic life, governmental regulatory action, and the quality of life. It is shown that there is reason for both optimism and pessimism about these various effects, and that considerably more analysis, research, and social experience will be required to foresee future developments and enable steps to be taken that will increase the chances of favorable outcomes.
>
> The concluding section provides some guidelines for research on the social effects of communication technology.(43)

SPECIAL PROBLEM IMPACT -- SECURITY/PRIVACY

One of the major special problems which can have very serious impacts on our society is the security/privacy problem. The impact of this problem is illustrated in items 13, 17, 19, 20, 37 and 38 of Exhibit 19, "Representative Table of Projected Impacts."

EXHIBIT 19
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPES(S)
(1) Computer Networks will be used for debiting and crediting accounts thereby producing an instantaneous exchange of money	The Year 2000: A Framework for Speculation on the Next Thirty-Three Years, by Herman Kahn and Anthony J. Wiener, 1967, p. 91	Last Third of the Twentieth Century	Economic
(2) Employers have terminals to record income and automatically transfer payments to tax authorities.	Forecast 1968-2000 of Computer Developments and Applications, Parsons and Williams, November 1968, p. 24.	Between 1982 and 1990	Economic
(3) Large urban traffic flow computer controlled.	Ibid., p. 25.	Between 1973 and 1979	Social and Environmental
(4) Policing of vehicles by combined radar and computer record of violation.	Ibid., p. 1.	Between 1980 and 1986	Social, Legal and Institutional
(5) Widespread use of automobile auto pilots.	Ibid.	late 1990's	Social and Economic
(6) Majority of doctors will have terminals for consultation.	Ibid., p. 2.	Early 1980's	Social and Medical

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREAS(S)/CATEGORY(S) TYPES(S)
(7) Well-established recording systems for medicine and other sciences with advances constantly updated.	Forecast 1968-2000 of Computer Developments and Applications, Parsons and Williams, November 1968, p. 2.	1983	Social and Medical
(8) Automated libraries and use of CAI.	Ibid., p. 2.	no date	Social and Educational
(9) Process control and attendant automation will reach higher degree of development and number of factory workers will drop precipitously.	The World in 1984, Volume I, edited by Nigel Calder, "Banishment of Paper-work," by Dr. Arthur Samuel, p. 146	1984	Economic, Social, Legal, and Institutional
(10) Computer simulation will be in regular use for economic policy making.	The World in 1984, Volume I, edited by Nigel Calder, "A World Dominated by Computer?," Dr. N. V. Wilkes, p. 149,	1984	Economic and Social
(11) 50% reduction of labor force in present industry.	Forecast 1968-200 of Computer Developments and Applications, Parsons and Williams, November 1968, p. 1.	Late 1980's	Economic, Social, Legal, and Institutional
(12) Depersonalization caused by high degree of standardization necessary.	Wall Street Journal, "What Else Will Computers Do to Us?," 21 October 1970.	no date	Social and Quality of Life

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/ TYPE(S)
(13) Privacy problems of personal data.	Wall Street Journal, "What Else Will Computers Do to Us?," 21 October 1970.	no date	Quality of Life, Goals, Values, Social, and Legal
(14) Starting grade clerical jobs being performed by computers raises job entry level.	Ibid.	no date	Economic, Legal, and Institutional
(15) Vulnerability to use for fraud and theft.	Ibid.	no date	Economic, Legal, and Institutional
(16) Problems of reliability (banking and exchanges, etc.)	Ibid.	no date	Economic, Institutional/Governmental
(17) Sabotage and industrial espionage applications.	Ibid.	no date	Economic, Legal, and Institutional
(18) Management becomes vulnerable through increased filtering of decision-making information through staff and other analysts.	Ibid.	no date	Economic, Governmental, Decision Making, Policy Analysis, Systems Analysis.
(19) Problem of privacy of business data.	The Real Computer: Its Influence, Uses and Effects, Frederic Withington, 1969, p. 272.	no date	Economic, Legal, and Institutional

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACTS(S) AREA(S)/CATEGORY(S)/ TYPE(S)
(20) Loss of personal privacy.	<u>The Real Computer: Its Influence, Uses and Effects,</u> Frederic Withington, 1969, p.257.	no date	Quality of Life, Legal, and Institutional
(21) Traditional organizational structures will break down.	<u>Ibid</u>., p. 268.	no date	Management, Decision making, Economic, and Social
(22) Further extension of computer-assisted decision making to more organizations and wider use in present computer using organizations.	<u>Ibid</u>., p. 299.	no date	Management, Decision Making, Economic, and Social
(23) Science of psychology will change; current work on information systems has brought us to threshold of breakthrough in learning theory.	<u>Man and the Computer: Technology as an Agent of Social Change</u>, John Diebold, 1969, p. 135.	no date	Social and Educational System
(24) New international trade patterns will evolve (emergence of multinational corporations.	<u>Ibid</u>., p. 136.	no date	Economic, International Politics, and Institutional
(25) Role of middle management will change.	<u>Ibid</u>., p. 138.	no date	Management, Decision Making, Economic, and Governmental

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACTS(S) AREA(S)/CATEGORY(S)/ TYPE(S)
(26) Computerized storage and retrieval of data bank information for legislative, and criminal justice agencies.	Forecast 1968-2000 of Computer Developments and Applications, Parsons and Williams, November 1968, p. 21	1970 Decade	Legal, Social, Economic, and Institutional
(27) The use of electronic monitors and computers integrated into day-to-day hospital operations.	Ibid, p. 29.	1974 to 1980	Medical, Social, Economic, and Quality of Life
(28) Completely computer controlled commercial airplanes including take-offs and landings.	Ibid, p. 32.	1975 to 1985	Economic, Quality of Life, Safety, Legal, and Institutional
(29) Computer industry will need close to 1.5 million workers.	Business Automation, "EDP Slated as World's Largest Industry," by Leonard Famiglietti, November 15, 1970, p.23.	1975	Economic and Social
(30) There will be well over a million jobs for "information middle-men" -- the interpreters of information demand.	Advanced Management Journal, "The Computer: Engine of the Eighties," by James H. Binger, January 1967, p. 25.	1975	Economic and Social

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S) TYPE(S)
(31) Simulation and games some of which are computer-based to help adolescents choose a career, train for management positions and perform other adult roles.	The Social Effects of Communication Technology, A Rand Report, by Herbert Goldhamer, R-486-RSF, May 1970, p. 11.	Late 1970's and 1980's	Educational, Societal, and Economic
(32) New communications technology enables political leaders and administrators to react faster to a crisis. Groups can confer more quickly if they need only to get to a special "secured" telephone than if they have to go to Washington.	Ibid., p. 15.	No date given but probably late 1970's and 1980's	Decision making, Management, Economic, Political, Legal, and Institutional
(33) The growth of computer networks "time-sharing for the masses" will make it possible to organize political districts on other than geographical lines -- perhaps more pluralistic society with individuals participating in many roles and associations.	Ibid., p. 13.	No date given but probably late 1970's and 1980's	Political, Quality of Life, Social, and Institutional
(34) Modern and advanced information and communications technology make it feasible to contemplate the success of political systems involving a large amount of decentralized free choice.	Ibid., p. 13.	No date given but probably late 1970's and 1980's	Political, Quality of Life, Social, Values, and Institutional

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPE(S)
(35) Possibility of manipulating computerized systems for counting votes.	The Social Effects of Communications Technology, A RAND Report, by Herbert Goldhamer, R-486-RSF, May 1970, p. 13.	No date given but essentially from the present on	Political, Social, Legal, and Institutional.
(36) Although computer companies and service centers sound confident about their ability to maintain confidentiality it is by no means clear that current schemes provide adequate protection.	Ibid., p. 16.	On-going	Legal, Economic, Political, Social, Quality of Life, and Institutional
(37) Criminal elements operating on Wall Street recruiting better educated people who know "how to steal with an IBM machine."	Ibid., p. 15 and 16.	On-going	Legal, Economic, Political, and Institutional
(38) National identification system coupled with computerized data bank facilitates surveillance of criminals -- or anyone else.	Ibid., p. 16.	1970's and 1980's	Legal, Political, Quality of Life, Social, Values and Goals, Governmental, and Institutional
(39) Management likely to develop corporate policy more self-consciously because businessmen will want to derive maximum advantages of the data storage and processing capabilities of the computers communication system.	Ibid., p. 18.	1970's and 1980's	Economic, Decision Making, and Management

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPE(S)
(40) Extension of computer control of manufacturing processes to permit on-line changes in product specifications to make customized products cheaper, for some products customization may become the rule rather than the exception.	The Social Effects of Communication Technology, A RAND Report, by Herbert Goldhamer, R-486-RSF, May 1970, pp. 19-20.	no date	Economic, Societal, and Quality of Life
(41) Economy of travel and professional time will increasingly dictate the use of computers and communication devices in place of direct contact between the professional man and his client.	Ibid., p. 24.	Late 1970's and 1980's	Quality of Life, Economic, and Social
(42) Large dependence of some social systems on computer-technology communication technology could lead to major difficulties in event of electronic error or because human servants of the machines are not up to their jobs.	Ibid., p. 25.	No date given but probably late 1970's and 1980's	Social, Quality of Life, Legal, and Institutional
(43) As a change agent, computers will enable the individual to seek maximum responsibility and self-actualization in a "society of organizations."	Doctoral Seminar in Management Literature, "The Interface of Computer-Based Information Network Technology with Top Management Decision Making and Organization Change: 1980-85," by Harold J. Podell, Dec. 16, 1970, p. 66.	1980 to 1985	Social and Quality of Life

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPE(S)
(44) The impact of the computer will be to provide the necessary economies of scale for information processes to support political organizational change.	Doctoral Seminar in Management Literature, "The Interface of Computer-Based Information Network Technology with Top Management Decision Making and Organizational Change: 1980-85," by Harold J. Podell, December 16, 1970, p. 68.	1980 to 1985	Political, Decision Making, Administrative, Legal, and Institutional
(45) More individual and capital productivity.	Ibid., p. 69.	1980 to 1985	Economic
(46) Shorter work week and more income per capita (direct and indirect income, e.g., salary and social benefits.	Ibid., p. 69.	1980 to 1985	Economic, Social, Educational, and Leisure-recreation
(47) Development of "nonroutine" industries that further reinforce the social and political impacts toward democracy in a large complex "society of organization."	Ibid.	1980 to 1985	Economic, Social, Political, and Institutional
(48) The demand for complex decisions will require top management to be aware of and to appreciate the value and dangers of the computers as a tool for decision making.	Ibid., p. 70.	1980 to 1985	Decision making, Administrative, Institutional, and Economic

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEOGRY(S)/ TYPE(S)
(49) Low cost <u>stored program</u> processors will link the local retail outlet to powerful central processors for inventory control and accounting.	<u>Fifteen-Year Forecast of Information-Processing Technology</u>, by George B. Bernstein, Naval Supply Systems Command, 20 January 1960, p. 95.	1970 to 1976	Economic, Legal, and Institutional
(50) Remote inquiry stations combining with television will provide over 50% of college education for engineering students.	<u>Ibid</u>.	1974 to 1983	Education, Quality of Life, and Economic
(51) Pattern reader used commercially in medical field analysis (hospitals).	<u>Ibid</u>., p. 52.	1971 to 1975	Medical/Health Service
(52) Low-cost computer hardware will justify ineffecient (by todays standards) but vast numbers of computation and handling processes.	<u>Ibid</u>., p. 55.	1972 to 1979	Social, Economic, and the Average Citizen
(53) Dependence on human observation and judgment in testing (computer) modules at the point of manufacture will be eliminated.	<u>Ibid</u>., p. 57.	1970 to 1980	Economic, both Higher Efficiency and the Unemploy-ment Problem

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPE(S)
(54) Cost/operation will drop by a factor of 200 from current levels (report published in early 1969) and will be available in 5th-generation computers.	*Fifteen-Year Forecast of Information-Processing Technology*, by George B. Bernstein, Naval Supply Systems Command, Washington, 20 January 1969, p. 58.	1974 to 1985	Economic, Management, Decision Making, Policy Analysis, Medical, Legal, Educational, and The Average Citizen
(55) Standard television sets will come into substantial use as I/O terminals.	*Ibid*., p. 63.	1970 to 1975	Average Citizen, Institutional, and Educational
(56) Development of low cost remote graphic terminals.	*Ibid*., p. 65.	1971 to 1976	Management, Decision Making, Systems Analysis, Medical, and Educational
(57) There will be a radical change in the policy and methods of publication. Copyright laws are a chief obstacle to wider publication in microforms, and publishing houses are struggling with the problem, but with an eye very solidly on the possibility of microform publications.	*Ibid*., p. 81.	1972 to 1977	Institutional, Legal, Economic, Political, Decision Making, Medical and Average Citizen

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/ TYPE(S)
(58) There will be a sequence of small languages relating small groups of people to machines,and groups of machines. This comment is based on the premise that, for example, there is no need to force physicists to talk the same language as biologists.	Fifteen-Year Forecast of Information-Processing Technology, by George B. Bernstein, Naval Supply Systems Command, Washington, 20 January 1969, p. 86.	1969 to 1980	Decision Making, Analysis, Legal, Medical, and Economic
(59) Widespread use of graphics systems for management planning. Display consoles available to managers and their staff providing access to the accumulated information resources of the country.	Ibid., p. 94.	1971 to 1980	Management, Decision Making, Policy Analysis, Political, Institutional, and Economic
(60) On-line color TV will permit computer user to "tune-in" and follow the course of his problem in real-time.	Ibid., p. 94.	1975 to 1985	Management, Decision Making, Administration, Systems Analysis, Policy Analysis, Medical, and Educational
(61) Systems providing access to the "library" type data with hard copy output via simple electronic I/O device (direct transmission) will be operational on a local city basis.	Ibid., p. 94.	1973 to 1981	Educational, Analysis

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT (S) AREA(S)/CATEOGRY(S)/TYPE(S)
(62) Computers with many (thousands) remote terminals netted together across nation and world-wide doing cooperative problem solving.	<u>Fifteen-Year Forecast of Information-Processing Technology</u>, by George B. Bernstein, Naval Supply Systems Command, Washington, 20 January 1969, p. 95.	1973 to 1980	Decision Making, Administration, Management, Policy and Systems Analysis, Medical, Political, Educational, Institutional, and Economic
(63) Instead of buying books and going to libraries for information, a student will be issued a reader and complete sets of microfilm with his entire course of study and all of the associated reading materials. The cost would be sufficiently low that the convenience to him would be worth the cost. The ability of microfilm to be distributed quickly and easily and updated would make it possible for additional materials to be handed out easily and quickly to be added to the collection in case the art is advancing or additional materials become available.	<u>Ibid</u>., p. 96.	1972 to 1980	Educational, Institutional, Medical and Legal
(64) Use of microforms in the home will be accelerated by merchandising in color microfiche catalogues read on home TV viewers.	<u>Ibid</u>., p. 96.	1972 to 1978	Economic, Institutional, and the Average Citizen

EXHIBIT 19 (Continued)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/TYPE(S)
(65) Man-machine capabilities to allow a user to examine in greater detail, at various levels, the output results of management information reports. With this would also come the opportunity to experiment more with overall results by causing changes in variables used in projecting from the bases established by using this stored information. The result would be a greater understanding by the user of the methods used to derive the information and what variables cause changes in what areas.	Fifteen-Year Forecast of Information-Processing Technology, by George B. Bernstein, Naval Supply Systems Command, Washington, 20 January 1969, p. 97.	1970 to 1977	Management, Decision Making, and Analysis
(66) Management not making use of management information and control systems which are real-time current awareness call up systems will not be able to perform competitively.	Ibid., p. 97.	1970 to 1975	Management Decision Making, and Policy Analysis
(67) 80% of work running on computers will be of a synergistic/symbiotic type.	Ibid., p. 98.	1974 to 1985	Decision Making, Analysis, Medical, Economic, Legal, And Educational

EXHIBIT 19 (Concluded)
REPRESENTATIVE TABLE OF PROJECTED IMPACTS

REPRESENTATIVE LIST OF PROJECTED IMPACTS FROM THE LITERATURE	REFERENCE	TIME FRAME	PRIMARY IMPACT(S) AREA(S)/CATEGORY(S)/ TYPE(S)
(68) Powerful question-answering systems will be developed which can assimilate thousands of facts and algorithms and efficiently develop long deductive chains of these to prove a result.	_Fifteen-Year Forecast of Information-Processing Technology_, by George B. Bernstein, Naval Supply Systems Command, Washington, 20 January 1969, p. 98.	1970 to 1976	Analysis, Decision Making, Medical, Legal, Institutional, and Political
(69) Marriage of computer-aided instruction techniques with standard information processing technology to effect error handling and reference manuals through user training.	_Ibid_., p. 100.	1972 to 1980	Educational, Legal, Medical, Management, and the Average Citizen
(70) Development of more powerful capabilities in man-machine areas which lead, instruct and assist the user in obtaining desired results primarily via the use of CRT consoles in on-line, real-time situations.	_Ibid_., p. 101.	1970 to 1977	Decision Making, Analysis, Educational, Institutional, Medical, Legal, and the Average Citizen

LISTING OF THE REFERENCED WORKS FOR EXHIBIT 19
A REPRESENTATIVE TABLE OF
PROJECTED IMPACTS

1. George B. Bernstein, A Fifteen-Year Forecast of Information-Processing Technology, AD681-752, Naval Supply Systems Command, Washington, D. C., 20 January 1969.

2. James H. Binger, "The Computer: Engine of the Eighties," Advanced Management Journal, January 1967.

3. John Diebold, Man and the Computer: Technology as an Agent of Social Change, New York, Frederick A. Praeger, Publishers, 1969.

4. Martin L. Ernst, "What Else Will Computers Do to Us?," Wall Street Journal, 21 October 1970.

5. Leonard Famiglietti, "EDP Slated as World's Largest Industry," Business Automation, 15 November 1970.

6. Herbert Goldhamer, Editor, The Social Effects of Communication Technology, A report prepared for The Russel Sage Foundation, The RAND Corporation, R-486-RSF, May 1970.

7. Herman Kahn and Anthony J. Wiener, The Year 2000: A Framework for Speculation on the Next Thirty-Three Years, New York, The MacMillan Company, 1967.

8. Parsons and Williams, Forecast 1968-2000 of Computer Developments and Applications, Copenhagen, Denmark, November 1968.

9. Harold J. Podell, Doctoral Seminar in Management Literature, Decision Making, "The Interface of Computer-Based Information Network Technology with Top Management Decision Making and Organizational Change: 1980-1985," 16 December 1970.

10. Dr. Arthur Samuel, "Banishment of Paper-work," edited by Nigel Calder, The World in 1984, Volume I, Baltimore, Penguin Books, 1964.

11. Dr. N. V. Wilkes, "A World Dominated by Computer?," edited by Nigel Calder, The World in 1984 Volume I, Baltimore, Penguin Books, 1964.

12. Frederick G. Withington, The Real Computer: Its Influence, Uses and Effects, Addison-Wesley Publishing Company, Reading, Mass., 1969.

Security/Privacy Problem and Its Potential Impact

The following quotations indicate the seriousness of this problem and the potential harmful impact. The following quote from Westin presents the 1966-67 situation.*

> In July of 1966 the Gallagher Committee held its own hearings on "The Computer and Privacy," with the federal data-center proposal as its main topic. The committee was hostile to Dunn and Bowman, the Chairman calling the proposed data center a "monster," and "octopus," and a "great, expensive, electronic garbage pail." Mr. Eckler told the committee that the Census hoped to ask in 1970 for Social Security numbers so that in the future more data on income, family size, and residence could be compared. He indicated, however, that public pressure had probably precluded any question on religion.
>
> As the Gallagher hearings progressed, several points became clear about the proposed federal data-bank. Administration witnesses and computer experts indicated that the identity of the individuals and businesses reporting the data would have to be kept in the system so that the validity of the data could be assessed, shifts in population could be checked for demographic studies, and further questions could be asked of samples at a later time in order to clarify trends on a longitudinal basis. This eliminated the possibility that privacy could be assured rather simply by breaking all links between identity and data.
>
> It also became clear in the hearings that there was a difference of opinion among the experts on whether a data-bank for statistical purposes, with identities preserved, should be considered in any way comparable to an intelligence or dossier system, or whether data-banks were always potential intelligence systems capable of being used for that purpose by those having access to them.
>
> The immediate problem of the federal data-center was more or less settled when Administration spokesmen assured Representative Gallagher that no action would be taken to initiate such a center without presenting a full-scale proposal to Congress for approval in terms of both authorization and appropriations. Both the Congressmen and Administration witnesses agreed that safeguards of confidentiality and privacy ought to be designed into the system as well as written into law before any such center was initiated.

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*From Privacy and Freedom by Alan F. Westin. Copyright 1967 by the Association of the Bar of the City of New York. Reprinted by permission of Atheneum Publishers.

In the larger context, several witnesses stressed that the computer community had been unconcerned for far too long with the basic issues of privacy, Congressmen Gallagher stressed that there seemed to be no dialogue among computer people, behaviorial scientists, and constitutional experts, and the Committee members voiced the hope that the hearings would prompt such meetings in the future. One result of this suggestion was the creation of a committee on problems of privacy and the computer within the American Federation of Information Processing Societies (AFIPS), and the holding of a symposium on the subject at the national AFIPS convention during April, 1967. This was preceded in March by a three-day seminar meeting of leading computer experts, social scientists, law-enforcement officials, constitutional lawyers, and specialists on privacy.

In October 1966, the report of the President's Task Force on the Storage of and Access to Government Statistics (the Kaysen Committee) was made public. Unlike the Dunn report, this discussion emphasized the issue of privacy heavily, called for legislation to forbid all regulatory or law-enforcement use of data collected for statistical purposes, and recommended advance studies of ways to ensure confidentiality of personal data by technological and administrative means. The report concluded that, with such safeguards, a national data center was a highly desirable project and recommended that the Administration move ahead with it.

A third Congressional development in this period came from the Senate Constitutional Rights Subcommittee, which directed its attention to the collection of personal information by the federal government through the forms and questionnaires it required of federal employees and job applicants. The inquiry dealt briefly with personality tests, in a kind of "mop-up operation" from the 1965 hearings, then went on to medical forms, personnel history forms, special surveys of race and religion for equality compliance purposes, and questions about financial holdings for conflict-of-interest purposes. Senator Ervin said that his committee had never before received such a flood of complaints and protests from citizens on any issue as it had on the requirements that federal employees supply racial and religious designations. During 1966 and early 1967, Ervin announced various eliminations of personal inquiries by federal agencies under pressure from his committee, such as the dropping by the Civil Service Commission of its Medical History Form 89. This had asked federal employees questions about bed-wetting, pregnancies, homosexuality, and whether blood relatives had committed suicide, had been insane, or had suffered from hives. The Commission had been unable to defend the necessity of the form on medical grounds, and examples were documented of use of the form to discipline or discharge employees when the real reasons for such action had been non-medical. With thirty-five other Senators as co-sponsors, Senator Ervin introduced a general bill to protect the privacy of federal employees from unreasonable invasions by government officials. This bill covered personality testing, polygraphing, race-religion-and-national-origin questionnaires, and various other self-reporting inquiries as to income and political activity. Hearings on this bill were held in late 1966, but the real test of the measure was expected to come at the 1967-68 sessions of Congress.

THE COMPUTER AND PRIVACY

By the late 1960's large-scale data collection and processing of information about individuals and groups had been added to the American public's list of serious problems involving technology and privacy. For some, like the conservative editors of U.S. News and World Report, the computer promised to advance such unhappy developments as economic regulation, welfare activity, and government civil-rights enforcement by making them more efficient and thus even more distasteful. For others, such as liberals who do not ordinarily shudder at large-scale government activity in these areas, fears were raised by the prospects of government loyalty-security and law-enforcement activity. Reaching to each other from opposite ends of the American political spectrum, conservatives and liberals united in alarmed reaction at "computerized Big Brother."

Yet the fundamental thinking necessary to come to grips with the problems of the computer and privacy had not yet reached the public arenas as of 1967. (44)

The following quotation by Arthur R. Miller illustrates the problem of best data sources and original information data sources - the interaction of this problem with policy-making:

> The convenience of referring to computer-stored evaluations and increased time pressures may lead decision-makers to abdicate their responsibility for making important judgments in a rational, thoughtful manner or to return to original sources to verify, update, and seek out more or better data. True, most information users insist that they understand that the computer's utility and a data base's reliability necessarily are limited by the quality of the input, typically emphasizing their alleged awareness by reciting the maxim "garbage in, garbage out" (GIGO). Nonetheless, the hypnotic effect of being able to manipulate enormous data bases is likely to encourage people to use the computer as an electronic security blanket and to view it as a device for quantifying the unquantifiable.
>
> Some notion of the implications of using computerized personal data as an assist in policy-making can be divined from the following:
>
> > '[In New York a] ... computer, that had been fed accumulated information from bettors, police and other sources spewed out the names of eighty-six alleged bookmakers. Indictments followed. The machine had not only stored the information but had evaluated it. The government claimed that the three-year statute of limitations on the charges might have expired before human investigators could have evaluated the data.'
>
> A number of disturbing questions are raised by this application of cybernetics. If programming a computer to select names of people for criminal prosecution falls within the district attorney's well recognized (and virtually unfettered) discretion, is it time to impose some constraints on how that discretion is employed? In order to prevent the administration of justice from depending on the spin of a computerized roulette wheel, shouldn't we ensure that the use of the technology satisfies some minimal standard of computer science? By what process does the system manager determine that particular data have sufficient probative value to warrant being fed into

the computer and what weight should be assigned to individual items of information? How can we be certain that the official who has the authority to decide whether an indictment should be sought has enough understanding of the computer system to make a rational assessment of its output?

Nor should we ignore the real possibility that prejudice to the individual will not end with the decision to seek an indictment. Commenting on this particular computer application, a lawyer observed: '[T]he ... computer can tell you where the stars are going to be a million years from now. Do you think a jury is not going to believe that it can tell you where a bookie is in the Bronx?'(45)

The above quotation illustrates the problem of the certification of data both with respect to reliability of the original source and the possibility of errors when the data is transferred from one system and/or medium to another. Although this particular computer illustration may have been quite beneficial, nonetheless, the problem created by the aura of the "infallible computer" with respect to information about the citizen when used in a legal proceeding may cause a serious harmful impact.

The following quotation illustrates a brief comparison of the problem of computerized information versus the noncomputerized data:

> Storage of information in computerized form allows rapid retrieval and updating of files and drastically reduces the required storage space. However, information previously in the form of printed documents in locked file cabinets is now replaced by magnetization patterns on tapes and disks--they can be anonymously read, altered or erased without a trace of evidence that this has occurred. Hence, anyone that has gained access to the information system could, in principle, manipulate any information in the files--perhaps plant damaging information on a competitor, change bank accounts or copy trade secrets.
>
> The increasingly large number of on-line information systems and associated terminals provides increased access opportunities and may make penetration of these systems

appear profitable to a wider class of technically sophisticated but larcenously inclined individuals. Indeed, the "electronically perpetrated crime" appears to be characterized by a low physical risk, small probability of detection, anonymity, lack of evidence and a lack of applicable laws. Further, the level of expertise previously required for successful embezzlement has been reduced by simplification of business procedures for computerized operation. On the other side of the ledger we find, however, that the resources, both in equipment and know-how, required for successful penetration are considerably higher than those necessary for conventional burglaries or holdups.(46)

The following quotation illustrates a comparison of the computer data bank problem with some analogies to other innovated technology and their human problems:

> The main immediate danger is that we will continue to ignore this issue altogether because of technical infatuation with computers. There are, unfortunately, many precedents for this sort of thing. When the factories of the first Industrial Revolution were built, the machinery went through many technical improvements before much thought was given to the health or safety of its operators. Even now, we seem to be more preoccupied with the flying characteristics of SST's than with their effects on the quality of human life. With data banks there is the somewhat sinister additional danger that, unless the debate gets going in time, we shall hear no more--because it has been deemed too upsetting by a real-life Big Brother. (47)

Scenarios Which Illustrate Potential Harmful Impacts of Resource Sharing Computer-Based Information Systems

The following quoted scenarios illustrate how some of the negative impacts could occur:

> ### Scenarios for Theft and Embezzlement
>
> The following scenarios illustrate several techniques which may be utilized to penetrate [sic, perhaps should be perpetrate] fraud or embezzle funds in a resource-shared computer system.

Theft Using a Between-The-Lines Entry

Background

The XYZ Investment Company, a well established brokerage firm with international offices and operations, utilizes a real-time computer link to a bank for all transactions involving receipt or expenditure of funds. This includes payment to clients for securities sold for the client by the firm. The method of calling for disbursement involves:

1. Computer-to-computer authentication using the firm and customer account numbers
2. In-the-clear transmission of customer name, address and the amount to be disbursed
3. Date disbursement is to take place.

The above information was obtained by a college senior through conversations with the XYZ Investment Company's systems programmer during a "job interview."

Approach

The student takes the following actions:

1. Leases a very small computer and data phone
2. Connects the data phone in parallel with the leased data line between the bank and the broker
3. Writes a short utility program to provide between-the-lines entry into the bank-broker link
4. Establishes an account at the Paris branch of the bank.

Operation

Following a few days of monitoring the links, a between-the-lines disbursement order is sent to the bank following the normal disbursement order tape. To ensure that all normal error checking schemes will be thwarted, the student's program:

1. Adds to the normal order sent to the bank an order to disburse $2,500,000 to the account in France
2. Computes a new checksum for the modified message and transmits it
3. Deletes the false order from the retransmission of the data sent back to the broker so that neither party is aware that a between-the-lines entry has been made.

The student flies to Paris, withdraws the money, flies to Switzerland, deposits the money in a numbered account and, following his return to the U. S., arranges for pickup and return of the leased computer and data set.

Embezzlement

Background

A computer operator in an investment firm decides to cash in on his position. The firm does not employ machineroom monitors.

Approach and Operation

1. The operator opens an account with the firm under an assumed name
2. During execution of the "customer account update" program, the operator stops the computer, decrements each of several large, inactive accounts held in street name by several hundred shares each and adds those shares to his account
3. The following day, he sells the securities and, on receiving the check for the proceeds, invests the amount with another brokerage firm or mutual fund
4. He closes the account used as a dummy for the transaction.

Revelation of Private Information

The following scenarios illustrate methods for obtaining private information, both actively and passively.

Wiretapping to Obtain Financial Data on a Firm as an Aid to Merger Negotiations (Mr. Boris Hagelin of Crypto A.G. made suggestions on which this scenario is based.)

Background

Firm A is a merger-minded conglomerate with some considerable experience in the merger field. It desires to acquire a smaller, privately held company - Firm B. Firm B's owners know that they cannot prevent the merger, but wish to consummate it on the most favorable terms possible.

Approach

Firm B finds out that Firm A uses a suitcase-sized data link device to its bank and to an investment banker in order to make use of computer programs that provide a matrix for negotiations showing a range of merger proposals and their effective cost. Firm B buys a similar suitcase sized data terminal and covertly attaches it, in parallel with that used by Firm A.

Operation

Firm B now receives all merger data that is sent to or received from Firm A. Upper and lower bounds for the transaction are revealed as well as insight into A's strategy. With this a-priori knowledge, Firm B negotiates the best possible merger agreement.[48]

The several quotations above reveal the widespread concern among knowledgeable people about protecting the security and privacy of information in data banks. It seems clear that one should expect an intolerable number of abuses of human rights unless adequate safeguards are developed to provide the requisite security and privacy.

CHAPTER VI

ACTION OPTIONS AND RECOMMENDATION FOR FUTURE RESEARCH AND DEVELOPMENT PROGRAM

ESTABLISHING A CONTEXT FOR ACTION OPTIONS

In order to establish a framework for proposing and discussing action options it is necessary to postulate the state of affairs in the nation. Whenever one writes favorable scenarios or postulates future impacts for the computer-based information processing network system, there is, whether explicitly or implicitly, a transition scenario. A transition scenario for the purpose of our discussion would be as follows:

(a) A favorable governmental policy exists for both computer and communications industries.

(b) The economic conditions of the next decade include an expanding economy with no major depressions and, at most, a few relatively minor recessions.

(c) There is no catastrophic nuclear war.

(d) The general society learns to accept computer systems and the advanced applications as a benefit rather than dreading the computer as a technological evil. The various computer hardware and software vendors continue to expand in the direction of joint computer communication systems.

In addition, during the transition time frame, primarily the 1970's, computer system achievements such as those described in the following quotation by Paul Armer are accomplished:

Various projections have been made of computer achievements in the 1970's. Let us note one such set of expectations.

- Computers will be readily available as a public-domain service (but not necessarily as a regulated monopoly).
- Information *per se* will be inexpensive and readily available.
- Large and varied data banks will exist and be accessible to the public.
- Computers will be used extensively in management science and decision making.
- Computers will be economically feasible for firms and activities of all sizes.
- Computers will process language and recognize voices.
- Computers will be used extensively at all levels of government.
- Computers will increase the pace of technological development.(49)

After this transition or sequence of events a continuation scenario, which might be an application or impact scenario, would contain a credible set of events for the 1980 to 1985 time frame. This would include the following types of systems:

(a) medical information and diagnostic networks

(b) legal information networks

(c) educational information and research networks

(d) social welfare including employment placement networks

(e) investment and securities trading networks

However, for all these events to occur in a reasonably rational manner with progress being made in the acceptance of computer applications without major catastrophes to our human value systems (security/privacy, rate of unemployment), and without severe bitterness and dislocations caused by major system failures both in operation and implementation, there must be a coherent set of action options and a plan for a continued inquiry as to the related course of events, and, as indicated, a research and development program.

Action options are methods for implementing societal desires relative to technology applications. They include:

(a) control options which accelerate or dampen an anticipated technology application

(b) monitoring or warning systems which track or measure an anticipated technology application

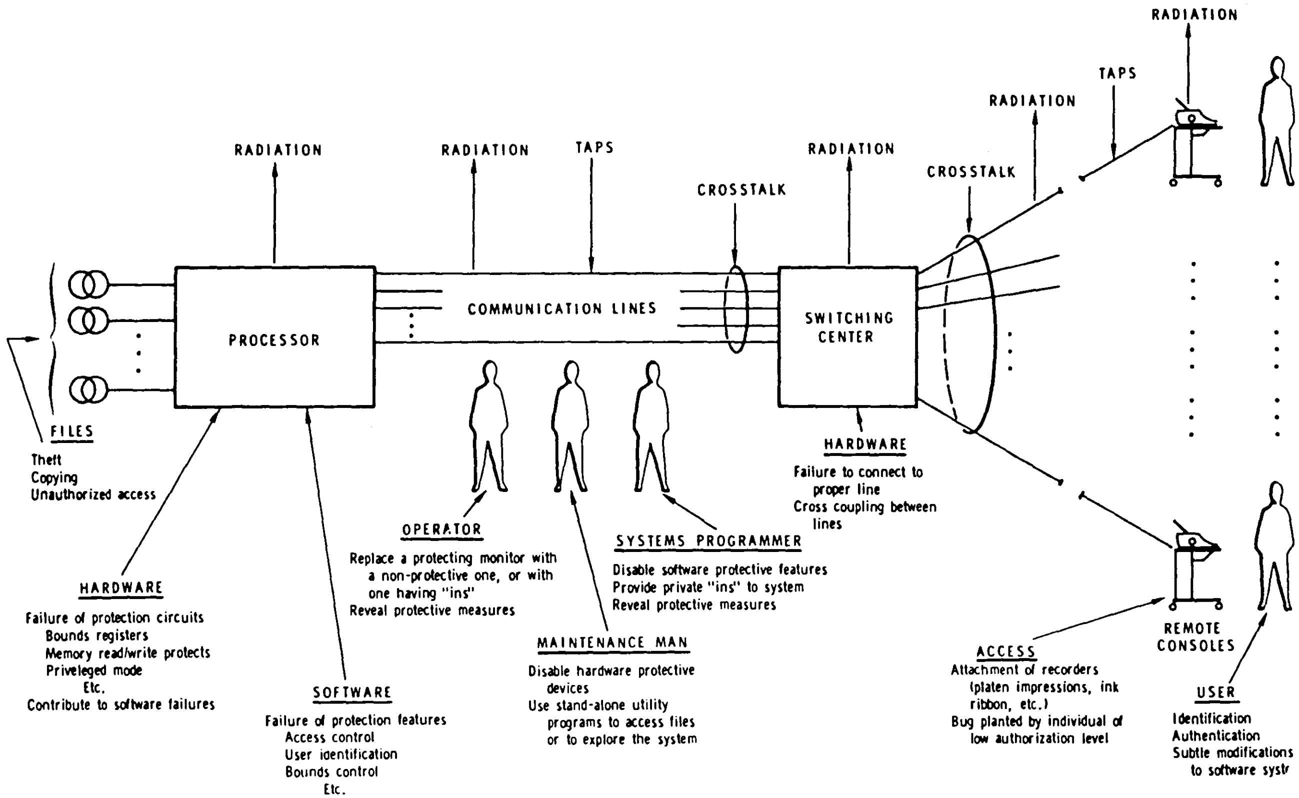
(c) obviating devices which counteract the undesirable impacts of an anticipated technology application

GUIDING DEVELOPMENT OF COMPUTER TECHNOLOGY

Control Options

One of the most serious and complex problems is the security/ privacy issue with respect to computer-based information networks. On the one hand, many of the institutional forces that wish to oppose modern innovative analysis and techniques including data bank utilization and multiple access systems can use the issue of security/ privacy to block the development of proposed systems. But on the other hand, it is a very real problem, and the reader is referred to Westin's Privacy and Freedom[50] and also Annette Harrison's two-volume study The Problem of Privacy in the Computer Age: An Annotated Bibliography.[51] Harrison's second volume alone annotates more than three hundred publications pertaining to all aspects of the problem of privacy in the computer age. Most of these entries cover the timespan 1967 to 1969.

Exhibit 20 illustrates in graphic form some of the many security threats which confront a computer-based information network. A summary illustration of many of the threats and countermeasures to information privacy/security is presented in exhibit 21.[52] It has been stated in the technology assessment literature that when analysts from the so-called "hard sciences" address a problem, they



Source: Willis H. Ware, "Security and Privacy in Computer Systems," AFIPS Conference Proceedings, Vol. 30, 1967 Spring Joint Computer Conference, p. 280.

EXHIBIT 20
TYPICAL CONFIGURATION OF RESOURCE-SHARING COMPUTER SYSTEM

EXHIBIT 21
SUMMARY OF COUNTERMEASURES TO THREAT TO INFORMATION PRIVACY

COUNTERMEASURE / THREAT	ACCESS CONTROL (passwords, authentication, authorization)	PROCESSING RESTRICTIONS (storage, protect, privileged operations)	PRIVACY TRANSFORMATIONS	THREAT MONITORING (audits, logs)	INTEGRITY MANAGEMENT (hardware, software, personnel)
Accidental: User error	Good protection, unless the error produces correct password	Reduce susceptibility	No protection if depend on password; otherwise, good protection	Identifies the "accident prone"; provides post facto knowledge of possible loss	Not applicable
System error	Good protection, unless bypassed due to error	Reduce susceptibility	Good protection in case of communication system switching errors	May help in diagnosis or provide post facto knowledge	Minimizes possibilities for accidents
Deliberate, passive: Electromagnetic pick-up	No protection	No protection	Reduces susceptibility; work factor determines the amount of protection	No protection	Reduces susceptibility
Wiretapping	No protection	No protection	Reduces susceptibility; work factor determines the amount of protection	No protection	If applied to communication circuits may reduce susceptibility
Waste Basket	Not applicable	Not applicable	Not applicable	Not applicable	Proper disposal procedures
Deliberate, active: "Browsing"	Good protection (may make masquerading necessary)	Reduces ease to obtain desired information	Good protection	Identifies unsuccessful attempts; may provide post facto knowledge or operate real-time alarms	Aides other countermeasures
"Masquerading"	Must know authenticating passwords (work factor to obtain these)	Reduces ease to obtain desired information	No protection if depends on password; otherwise, sufficient	Identifies unsuccessful attempts; may provide post facto knowledge or operate real-time alarms	Makes harder to obtain information for masquerading; since masquerading is deception, may inhibit browsers
"Between lines" entry	No protection unless used for every message	Limits the infiltrator to the same potential as the user whose line he shares	Good protection if privacy transformation changed in less time than required by work factor	Post facto analysis of activity may provide knowledge of possible loss	Communication network integrity helps
"Piggy-back" entry	No protection but reverse (processor-to-user) authentication may help	Limits the infiltrator to the same potential as the user whose line he shares	Good protection if privacy transformation changed in less time than required by work factor	Post facto analysis of activity may provide knowledge of possible loss	Communication network integrity helps
Entry by system personnel	May have to masquerade	Reduces ease of obtaining desired information	Work factor, unless depend on password and masquerading is successful	Post facto analysis of activity may provide knowledge of possible loss	Key to the entire privacy protection system
Entry via "trap doors"	No protection	Probably no protection	Work factor, unless access to keys obtained	Possible alarms, post facto analysis	Protection through initial verification and subsequent maintenance of hardware and software integrity
Core dumping to get residual information	No protection	Erase private core areas at swapping time	No protection unless encoded processing feasible	Possible alarms, post facto analysis	Not applicable
Physical acquisition of removable files	Not applicable	Not applicable	Work factor, unless access to keys obtained	Post facto knowledge form audits of personnel movements	Physical preventative measures and devices

SOURCE: 1967 SJCC AFIPS Conference Proceedings (Volume 30) suggest hardware or an engineering solution. When analysts from the so-called "soft sciences" are confronted with problems, they suggest new legislation and laws for problem solution. The approach taken here is a combination of technical and legal solutions.

Some of the public policy/legal control options that could be invoked to accelerate and maximize the beneficial impacts of the technology and to delay the adverse impacts are the following:

(a) legislation to require holders of data banks to inform citizens of information held and permit those people to examine and correct information

(b) system certification procedure whereby a data processing installation could demonstrate through outside inspection by an official certification group (government and/or industry) that it has met proper security/privacy standards

(c) licensing of personnel handling "sensitive" information

(d) insurance and/or bonding, if appropriate

A program of strong federal governmental participation in this area is being recommended by many organizations in our society, but some would prefer that only a minimal control effort, perhaps at the local level, be implemented or even that the action of the market place essentially solve the problem in its own manner. An example of the comparison of these two concepts is illustrated in Exhibit 22.

Actually, it is quite probable that various communities of users would develop and enforce specific security/privacy policies. This means that the defense community would have its policy and procedures for security/privacy, the law enforcement community and the health service and medical community would each have its policy and procedures for security/privacy. There would be a strong interaction

EXHIBIT 22
STRONG NATIONAL PROGRAM VS. LOCAL OPTIONS OR ORDINARY MARKET PLACE ACTIONS RE SECURITY/PRIVACY

ACTION OPTION / CRITERIA	STRONG FEDERAL PROGRAM	MARKET PLACE AND LOCAL PROGRAMS
(1) Controllability	There is a relatively high probability that the problem of violation of security/privacy can be significantly altered if adequate resources (planning, R&D, and legislation all at the national level) are allocated.	Although some think that the operational market place or a local control could handle the problem, nonetheless, this does not seem to be very realistic.
(2) Worth	The advocates for a strong federal program have considerable support from the information presently available to indicate that action should be taken.	The advocates for the minimal control position either feel that a minimal alteration is sufficient or that perhaps no outside effort is required.
(3) Priority	This would be one of the highest priority items ranking close to and perhaps at the top.	Relatively low priority.
(4) Effectiveness	This control option should have a major impact on reducing the security/privacy problem.	There might be some reduction in the security/privacy problem but it would probably remain as a major liability.
(5) Cost (Sponser)	The derivation of the costs would be one of the objectives of the R&D program described later in this chapter.	This again would be the subject of a R & D effort. Although the direct cost may be minimal, the indirect costs of various types of damages could be quite large.

EXHIBIT 22 (Concluded)
STRONG NATIONAL PROGRAM VS. LOCAL OPTIONS OR ORDINARY MARKET PLACE ACTIONS RE SECURITY/PRIVACY

ACTION OPTION / CRITERIA	STRONG FEDERAL PROGRAM	MARKET PLACE AND LOCAL PROGRAMS
(6) Nonfinancial Problems	Again, the subject of R&D program, but there may be additional administrative or overhead problems.	Again, this requires additional R & D because, although on the surface this option may have minimal indirect problems, still the impact of the security/privacy issue itself could be enormous.
(7) Institutional Obstacles	Requires new legislation, probably a new administrative system or at least a modification of the interaction of some of the government agencies.	Minimal institutional obstacles -- indeed, institutional obstacles may very well be the major force backing this option.
(8) Uncertainty	Considerable uncertainty with respect to the details of solutions, and therefore, a major objective in the R&D program plan.	Considerable uncertainty with respect to the claims that minimal effort is adequate.

between technology oriented (computers and communications) organizatons/agencies and the user communities.

A specific procedure which might be implemented regarding the security/privacy problem and its solution for the types of users described in this study (i.e., doctors, lawyers, educators, decision makers, systems and policy analysts, the average citizen) is the decoupling of the user and the system. Since these classes of users in general would have no requirement to know the specific detail innerworkings of the system, they can use it as a virtual "black box." The system would speak his vocabulary -- medical terms to doctors, legal terms to lawyers, etc. It also means that these users would be restricted to higher order languages and query languages, and that they would be permitted to use only "completely" checked out compilers and systems. Wherever feasible, debugging, testing, installing and certification of new systems and modifications should be decoupled from the user and his environment.

To be effective, this procedure would have to be strictly enforced. In addition, for the projected time frame, 1980 to 1985, the advances in technology, (increased speed, decreased cost, and decreased size) should be utilized to enhance the security of systems by including redundancy of critical security system elements and encryption of the data bank itself. This would be a protection against unauthorized access, either by on-line consoles or by special analysis of removable storage media. This system's design would include backup files and redundant encryption equipment for continued operation and protection against losing good information in encrypted form because of the malfunction of an encryption device. Again, as a matter of policy, the system security/privacy must be included as a major goal from the very conception of the initial design and be carried forward through implementation and final test and evaluation as one of the primary system objectives. In addition, as a matter of policy, those individuals concerned with designing, programming, testing, operating, and managing/controlling the system should receive the equivalent of security clearance checks and investigations. The depth of these investigations would be determined by cost/benefit considerations including, but not necessarily restricted to, the sensitivity and value of the system's information. Finally, there should be established a "devil's advocate," "break-in," test team which is composed of knowledgeable individuals who are adequately motivated to perform in the role of the "opposition," whoever they may be.

Additional information with respect to the security/privacy problem is included later in this chapter.

Monitoring Systems

When one considers a field as vast as that projected for the computer-communication technology for the next 10 to 15 years, it is rather obvious that a strong monitoring system would be necessary, and that it would feed into a research and development program for technology assessment. One of the major areas that should be monitored is unemployment due to computer/automation. The actual unemployment figures and their causes should be gathered and analyzed on a continuing basis. The same is true for statistics on various legal cases resulting from computer system failures when in an operational condition, or failure of a computer-based system to perform within contractual requirements. Another item in the monitoring category would be the collection of general information and statistics with respect to the improved performance of the computer-communications industry of the Soviet Union. This would include performance data on their central planning network with its planned 800 computer centers. Another monitoring category would be observation of advancement in the directed R & D efforts mentioned in Chapter II.

The function of the monitoring or warning system would be to collect information continually that is pertinent to the assessment of technology. For instance, if one were to assess the interaction between computer-communications networks and transportation and their effect on the general public and business community, the assessment would be assisted by information gathered through various types of surveys of appropriate segments of the population, as well as by direct collection of the following trend data:

(a) change in the number of automobiles purchased and produced

(b) employment in the automobile industry

(c) economic impact on industries related to the automobile industry, including unemployment

(d) change in the rail, bus and airline industries

(e) variations in related land use patterns

Although at first view these trends may seem rather far removed from the subject of computer-communications networks, it is precisely these effects which are envisioned by those forecasters who predict that in the future many professionals will be able to perform much of their work at home with the aid of a terminal in a computer-communications network. Even today, a professional person, who is engaged in programming as part of his activities, with a time-sharing computer terminal in his home could do much of his work there, and travel to his office on perhaps only one or two days of the week to receive additional guidance and to coordinate his efforts with those of others engaged on the same project. The trends would have to be measured and correlated with computer-communication networks by means of survey data in order to establish the existence and measure the magnitude of any impact on transportation caused by the computer technology. In addition, other information pertaining to the overall economic and transportation situation of the country would be gathered. A thorough analysis would be performed investigating various appropriate hypotheses including the computer communications network hypothesis but also including other potential causes for the trends illustrated by the collected data.

The objective would not be to preclude the advance of a new technology, but rather, from the point of view of anticipatory planning, to set up obviating devices, techniques, and procedures in the overall national interest.

Obviating Devices

There are many potentially obviating devices and two examples are legislative and educational. Appropriate legislation would allow an individual who might be injured through lack of privacy/ security in a data bank system to sue for and receive civil damages, or punitive damages. This would be a method of compensating individuals for the misuse, unreliability, or perhaps exceptional-case failure.

It can be observed that a major obviating device, pertaining to the general computer technology problem, is more and proper education for both adults and school children. Some of this will occur naturally when computers and, in particular, computer terminals are installed in the general educational system,including colleges and universities, high schools, and elementary schools. There is a need, however, for additional information at the adult level and courses in the curriculum of the general school system which would give correct information on the capabilities and problems of computers for a variety of real-world applications which the student will encounter in later life. This would include such later life encounters as income tax filing, bill payment, automatic control devices, and proper explanation of advanced automated/adaptable computer systems (artificial intelligence, chess playing, and the like). This education should specifically illustrate that computers are not infallible and should include discussions on such problems as errors in input data, system complexity, and program debugging problems.

If the general public were properly educated regarding the limitations and capabilities of computers, if they were not objects of mistery, then there probably would be less public resistance to appropriate utilization of these useful devices. Also, a well-informed public would be in a good position to insist on the development of adequate safeguards to protect the citizenry from misapplication of the technology. Furthermore, when a problem does arise, an informed individual will be in a better position to place the blame where it belongs.

Concerning the dehumanizing of personal services, for example, the medical profession, the computer can be illustrated as the doctor's assistant and not some robot which would automatically make decisions on life and death issues such as major operations or final critical diagnosis.

There has recently been discussion of the publication of misinformation on the capabilities of computers.[53] A program of education for the generatl citizenry beginning at early ages and continuing at all levels would go a long way toward alleviating such problems.

REPRESENTATIVE CATEGORIES OF USERS AND APPLICATIONS

To enable the analysis to be focused, a representative set of applications and users has been chosen as an appropriate point of departure in this methodology development pilot study. In addition to the applications/users classes defined below, the average-citizen category was chosen to give essentially a general indication of the overall impacts both positive and negative. The average-citizen category can be subdivided or extended for particular applications when this becomes relevant and consistent with resources.

The representative applications/users classes chosen are as follows:

(a) Decision maker/decision making -- This includes the use of the computer communication technology for such decision-making organizations as the U.S. Congress and the general Federal Government decision-making officials, as well as complex decision making at various levels throughout our society.

(b) Policy sciences/analysis and systems analysis -- This category is complementary with the decision-making process and, in certain cases, the two classes will blend together.

(c) Professions--medical, legal, educational--This includes a very broad or generic definition of the terms involved. Medical includes: medical schools, hospitals, private practitioners, group health organizations, and the general administration of health and health delivery system of our society including medical research and development efforts. The legal area includes the administration of justice, crime prevention, the court systems, criminal detection, apprehension, conviction and rehabilitation. Educational includes the entire educational system, both formal and informal, adult education, training and retraining, the universities, the business schools, colleges, elementary and secondary schools, and home education. These user classes can also be thought of as user communities. Some examples are the educational community, the law enforcement community, and the health service community.

When reporting on the analysis of the data collected, there are three terms which sometimes can be used to differentiate the state of technology and its application. The following are presented as working definitions for the purposes of this paper.

(a) Technological perfection -- This is considered to be somewhat similar to "an initial operating capability." It essentially means that the technology has been "perfected" well enough to be used in an initial operational sense for prototype, proof-testing, pilot operation, and initial trials; i.e., beyond the R&D stage and entering into operation.

(b) Initial application -- The particular technological advance or innovation is being used by at least a small percentage of the potential market in an operational sense and that the technology is a step beyond the technological perfection stage. This step beyond may be in terms of acceptance of the innovation as well as the advances in technology "reliability."

(c) Full application -- This means that the technological innovation has been accepted by a substantial number of potential users, perhaps greater than 50 percent. It also means that some of the institutional barriers with respect to social, political, and psychological inertia have been overcome; and that the cost-effectiveness, reliability, and general operational performance are in a fairly satisfactory state for operational, user-oriented application of the technology.

Among the types of questions that are included in impact analysis are:

(a) How likely or certain is it that a specific impact will actually occur?

(b) How soon after the development of a technology would the impact be felt?

(c) In what direction would an expected impact be favorable or unfavorable?

(d) What would be the magnitude of this impact, slight or great?

(e) How long would the impact endure? Would the initial impact be self-reinforcing or self-reducing?

(f) On whose initiative would the impact be generated, industry, government, scientific community, etc.?

(g) How controllable is the impact?

Preliminary assessment with respect to these questions is illustrated in Exhibit 23, "Impact Parameters of Computer Technology with Respect to Appropriate User Classes." Various impacts were considered, including economic, social, environmental, health, defense, attainment of national goals and setting of priorities, etc. They are seen as the result of application of computer technology in the area chosen as a proxy, namely, computer-based information networks. The preliminary classification of the population into the above described four areas is based on judgment with respect to methodology development and impacts, benefits and/or problems.

The entries in the matrix of Exhibit 23 represent the results of a "summation" across several impact areas. In a similiar matrix relative to a single impact area, there normally would be greater differences among the entries, pertaining to a given parameter, for different user classes. When examining the aggregation of impacts in several areas; however, it can be noted from the first row of the matrix that it is "highly likely" that each of the four classes of users will experience impacts from computer-communications networks. From the second row of the matrix it can be observed that the impacts will occur first in the policy sciences, policy analysis, and systems analysis areas; second in decision making, medical, legal, and educational areas; and later the average citizen will be affected directly by the technology when it comes into full application. The third row of the matrix shows that, before control is implemented, all of the user classes will experience both favorable and unfavorable effects from the computer-based networks. Similar uniformity across user groups is revealed by the fourth row of the matrix which indicates that the impacts will be highly controllable if planned for from the beginning. The fifth row shows that for the average citizen the impacts will be of only medium magnitude, while for the remaining user groups the magnitude is potentially great for both favorable and unfavorable impacts. The last row of the matrix indicates that for all user classes the duration of impacts will be from 1980 to 1985 and beyond if evaluation and acceptance of the technology is good.

A summary of the institutional factors relevant to this technology assessment is presented in Exhibit 24, "The Relationship Between Institutional Factors and Relevant Application Classes." This table gives an illustration of the types of institutional factors which might impede the full and rapid application of the new technology being assessed.

The information in Exhibits 23 and 24 is highly aggregated and is in qualitative form but, nonetheless, paints a "point-of-departure" picture.

The key to this technology assessment of computers is the realization that the computer is essentially the "machine" that drives the computer-based information network, and that it is the information and its analysis which are of fundamental importance with respect to policy making and implementation. The higher-level decision making and analysis are of major importance with respect to such areas as economic welfare of the country or the social-political structure of the country.

As an example of the impact of computers one might "reverse the arrow" and use computer technology or the computer-based information network as an innovative tool for the task of technological assessment in general. There would be devised, planned, and implemented a system which would include the following:

(a) various mathematical and statistical routines for multiple regression, modeling, etc. (forecasting, projections, evaluating impact)

EXHIBIT 23
IMPACT PARAMETERS OF COMPUTER TECHNOLOGY WITH RESPECT TO APPROPRIATE USER CLASSES -- WITHOUT ACTION OPTIONS*

IMPACT PARAMETERS \ APPLICATION CLASSES	DECISION MAKER DECISION MAKING	POLICY SCIENCES/ ANALYSIS SYSTEMS ANALYSIS	PROFESSIONS - MEDICAL, LEGAL, EDUCATIONAL	AVERAGE CITIZEN
Likelihood of specified impact	Highly likely	Highly likely	Highly likely	Highly likely
Lag time after technology development	Between initial and full applications time-frame	Between technological "perfection" and initial application time-frame	Between initial application and full application time-frame	Approximately full application time-frame
Impact direction - favorable, or unfavorable	Both favorable & unfavorable before control is implemented	Both favorable & unfavorable before control is implemented	Both favorable & unfavorable before control is implemented	Both favorable and unfavorable before control is implemented
Controllability of impact	High if planned for from the beginning	High if planned for from the beginning	High if planned for from the beginning	High if planned for from the beginning
Magnitude - slight or great	Potentially great in both directions	Potentially great in both directions	Potentially great in both directions	Medium and perhaps more unfavorable than favorable
Duration of impact	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good

*Exhibits 23 and 24 are presented for comparison or contrast with Exhibits 27 and 28. Taken together they give a preliminary illustration of the situation before and after public action options are implemented. These four tables also illustrate the general commonality of obstacles and impacts across application classes and user groups. There are, however, differences in the details which would become evident when specific studies are performed.

EXHIBIT 24
THE RELATIONSHIP BETWEEN INSTITUTIONAL FACTORS AND RELEVANT APPLICATION CLASSES -- WITHOUT ACTION OPTIONS*

APPLICATION CLASSES / INSTITUTIONAL OBSTACLES	DECISION MAKER DECISION MAKING	POLICY SCIENCES/ ANALYSIS SYSTEMS ANALYSIS	PROFESSIONS - MEDICAL, LEGAL, EDUCATIONAL	AVERAGE CITIZEN
Political	Quite great until either new personnel or considerable education	Considerable unless background or interests relevant to the technology	Considerable until major educational program	When applicable, mostly lack of information
Legal	Quite great before adequate controls implemented	Quite great before adequate controls implemented	Quite great before adequate controls implemented	Where applicable, problem of misuse and exploitation
Administrative/ Organizational	Can be great if innovative organizational structure recommended	Function of specific application	Potentially quite great if innovative organizational structure recommended.	Considerable resources may be required
Social/psychological inertia and custom/ tradition	Quite great - will require perhaps cultural reeducation	Medium level problem	Quite great and may require considerable time	Potentially very great because of lack of information and overabundence of misinformation

*Exhibits 23 and 24 are presented for comparison or contrast with Exhibits 27 and 28. Taken together they give a preliminary illustration of the situation before and after public action options are implemented. These four tables also illustrate the general commonality of obstacles and impacts across applications classes and user groups. There are, however, differences in the details which would become evident when specific-studies are performed.

(b) the design and implementation of such techniques as the on-line multiple-access DELPHI capability

(c) the data bank devoted to assessment of various areas of technology which would include: whole text, abstracts, results of former studies or case histories, etc.

(d) data bank information and computer programs for producing the macro- state-of-the-universe and potential scenarios. This would include the census data and results of other surveys

(e) the capability to obtain information from various data banks regarding new technology for updating older information

(f) a subsystem for computer-assisted text editing which would reduce the time requirements for the production of interim and draft reports for their review and evaluation. The potential and relevance of such a system are illustrated by Dr. Edward David, Jr., in the following quotation:

> I am one of those people for whom writing an article involves much editing and rewriting. My secretary may actually retype the complete manuscript three or four times, and she may spend up to a couple of days working on it. So in preparing this article, I decided to push the burden of retyping off onto a digital computer.
>
> Today, reaching a computer by telephone is no trick at all -- as a result of new techniques for sharing a computer's time, many people can use a single machine simultaneously from many locations. For this article, my secretary simply typed the first draft into a computer memory from a simple teletypewriter console near her desk. After that she made changes by first typing a code name to activate a special editing program, and then retyping only the revised words or sentences, indicating where in the manuscript they should go. The computer program inserted the new words in their proper places and typed out a complete clean manuscript, saving several hours of typing and proofreading time in the process.[54]

This system would be devised so that the computer technology would be of assistance to technology assessment, in general, and it is emphasized that such a proposed system would be user-oriented (i.e., vs. programmer-oriented) and would include a user-oriented vocabulary and on-line terminals. Such a system would be useful for systems and policy analysts in their technology assessments and also would be of assistance to both decision makers and the analyst when meetings are held to decide on alternative courses of action, i.e., action options with respect to a particular technology. This could result in recommendations for legislation as well as technical standards or executive orders.

There are several technological applications to major areas of national well-being. Some of these are listed in Chapter I. As stated there, this study includes a minimal investigation of various computer technology applications and an in-depth investigation of particular areas. Exhibit 25 illustrates some elements of the entire computer technology problem which would be of immediate concern to an R & D program. The words "major" and "minor" in that table mean either:

(a) the general impact will be major or minor

(b) the action options will require major or minor quantities of resources

The table illustrates a division into three categories: "major" which requires significant resources and/or will have a heavy impact; "minor," which probably will not require extensive study or significant resources; and "moot," which means that more information is needed for categorizing the element, and it will be placed in a warning or monitoring system category, i.e., they may become major within the time frame, and as additional information is gathered, an appropriate adjustment should be made in the R & D program.

EXHIBIT 25
RELEVANCY TABLE

IMPACT, PROBLEM OR BENEFIT	RELEVANCY WITH RESPECT TO IMPACT AND/OR QUANTITY OF RESOURCES NECESSARY FOR ACTION OPTION
Security and privacy for both the individual and organization	Major
Legal rights, "due process" and problems such as copyrights	Moot
Economic effect/unemployment/ automation	Moot
Diversity versus conformity with respect to citizen values and life styles	Minor (if handled properly)
New business and consumer services as well as improvements thereof	Probably minor (not that there won't be an impact but rather that major action implementation from the point of view of the nation/U.S. Government is probably not required)
Reducing the cost of services	Minor (again in a sense that major action resources need not be allocated to this impact -- the impact itself might be quite relevant and major depending upon individual services and their desirability in the cost/benefits sense)
Better utilization of certain scarce skills (e.g., medical personnel, decision maker/analyst personnel, policy analysts, legal personnel, educational personnel	Major
Reducing the drudgery associated with certain menial (e.g., clerical) tasks	Minor (in the sense of action option resources necessary -- this can be an important impact when taken in connection with some of the other impact complications)
Possible "dehumanizing" of consumer services (e.g., professional services or customer relations services)	Minor (in a sense that with proper education/explanation and analysis, this shouldn't require major resources for the action program envisioned)

RESEARCH, DEVELOPMENT, AND MONITORING PROGRAM PLAN

Summary of Requirements for RD & M Program

Conclusions reached during the Computer Pilot Study are as follows:

(a) Computer technology itself, including the projected computer communications, data banks, man-machine interaction, etc., is of such a scope that there is no possibility of a simple substitution of another technology and the real question is the guidance of the technology rather than its replacement.

(b) The main objective for technological assessment in the case of this pilot study would be to answer two major questions: First, what impending major problems are present or projected? And second, what opportunities for major potential benefits are being missed (or might be)?

(c) The method of measuring progress, both in the computer field and development of methods for technology assessment, is to establish research, development, and monitoring R & D programs for assessing computer technology. Program objectives should be defined to be consistent with the technological progress desired, and these on-going programs should be evaluated on a yearly basis. The evaluations would indicate progress made towards a full solution of the problems, or towards realization of the full potential of the innovative technology.

Sufficient Justification

The evidence in Exhibits 19 and 25 clearly indicates that there are sufficient grounds to instigate a research, development, and monitoring program. In addition, the discussion in Chapter V, Special Problem Impact -- Security/Privacy, indicates the seriousness of this one problem. Stating this another way, even though there is much uncertainty with respect to events a decade or more in the future, enough independent evidence has been gathered to project serious problems and major opportunities associated with computer technology. Such a program should begin at the earliest feasible time with the expectation that it would continue for the foreseeable future.

Research and Development Program Plan

The goals and objectives of the R & D effort would be made specific during the first year of the program, but would include, as a point of departure, an attack on some of the specific problems discussed in this study, and research to accelerate the progress towards innovations which would be particularly productive from the point of view of the professional person who is not an accomplished programmer. The mechanism of translating research and development in this area to national goals is the use of the key professions and communities of users as illustrated in Exhibits 23 and 24 and again in Exhibits 27 and 28. The time-frame for this proposed program would be in the 1970's and 1980's, and in reality, one could conclude that the time-frame should extend for the foreseeable future with varying allocation of resources depending on the criticality of present and projected problems and potential opportunities. There would be large-scale experiments which would be performed by the coordinated effort of science/technology-oriented organizations and mission-oriented organizations.

Some Specific Program Objectives and Ideas

A point-of-departure list of objectives which might be included in the plan to be developed during the first year of such a program is as follows:

(a) There should be a cost/benefit analysis of the security/privacy problem with respect to the value of the information protected and the cost of this protection. This can be a very complicated analysis because of several factors. The first one of which can be illustrated by the following quotation by Willis H. Ware:

> ... The state of the art for information safeguards in computer systems does not permit a handbook approach to the subject; only general principles and guidelines can be stated....(55)

Second, the value of information obtained from the data bank may be greater to the individual or organization breaking the security/privacy system than to those who are protecting the system. This may be particularly true in a commercial environment, if there were "third parties" or other parties who may be injured by those who have broken the system's security. This would indeed lead to the necessity for action options, such as strong governmental policy, including legislation which would ensure protection and/or redress to the injured parties.

(b) Research should be specifically directed towards the objectives listed in Chapter II under the heading, "Breakthroughs and Directed Research and Development Needed." (A major input for the setting of priorities and allocation of resources would be obtained from the monitoring of R & D progress in both government and industry.)

(c) The plan for an overall educational program, whose objectives are described herein would have to be developed.

(d) A method would have to be developed for thorough analysis of the interaction of various technology assessment impacts using on-line computer simulations and on-line Delphi Techniques. It is recommended that there be a detailed investigation of the applicability of Forrester's <u>Urban Dynamics</u> and <u>The Dynamo Compiler</u> for these analyses. A quotation from <u>Urban Dynamics</u> indicates that this might be a very fruitful area for research since some of the technology assessment impacts both in general and for computer technology include complex social, economic and national government areas:

> Complex systems have special responses which cause many of the failures and frustrations experienced in trying to improve their behavior. As used here the phrase "complex system" refers to a high-order, multiple-loop, nonlinear feedback structure. All social systems belong to this class. The management structure of a corporation has all the characteristics of a complex system. Similarly, an urban area, a national government, economic processes, and international trade all are complex systems. Complex systems have many unexpected and little understood characteristics.[56]

(e) Some of the ideas for analysis, research, and development found in Farquhar's Applications of Advanced Technology to Undergraduate Medical Education should be adopted. (57) (This report is particularly interesting because it was prepared as one portion of continuing research and concerns undergraduate medical education, describes alternative ways in which technology might increase both the quality and quantity of such education, and details a comprehensive plan for further study of this problem. This analysis interacts with the areas of medicine, education, and decision making/analysis. The following partial summary quoted from the article cited above illustrates part of what should be done.)

> This Memorandum concerns undergraduate medical education, and the ways in which advanced technology might bring about substantial changes in both the quantity and quality of graduates. Five such applications are described:
>
> 1. computer-assisted instruction;
> 2. computer-assisted self-evaluation;
> 3. an ultra-microfiche retrieval and display system;
> 4. Electronic Video Recording (EVR);
> 5. two multimedia aids known as the 'Clinical Encounter Simulator' and the 'Patient Management Decision Aid.'[58]

Point of Departure: Resources and Action Options

Although the initial program could be started at almost any level, it is suggested that appropriate resources for the first year's program would be on the order of five professional people with their required support personnel, terminals, machine-time, etc.

Exhibit 26 presents in tabular form a summary, with examples, of the action options being considered.

RESEARCH AND DEVELOPMENT PROGRAM EVALUATION

The evaluation procedure has as its objective a demonstration of the change, hopefully improvement, in the contribution of the technology (computer-communications, in this case) towards our national goals. There are many lists of potential national goals and a useful example is the following abbreviated statement of goals.[59] The list presented here is an abbreviated form of the goals listed in Reference (59).

(a) effective and efficient government

(b) peace

(c) eliminate poverty

(d) equal opportunity (education, housing, employment, voting)

(e) preserve environment

(f) family planning

(g) decent housing

(h) employment

(i) education

(j) health

EXHIBIT 26
TYPES OF ACTION OPTIONS

MAJOR CATEGORIES	EXAMPLES
Control Over R & D Funds	A monitoring system which would supply information regarding industry's performance in attaining the objectives listed in Chapter II as needed breakthroughs. Sufficient R & D funds then should be allocated to make up for any deficiencies in industry's progress.
Other Financial Incentive Schemes	Government grants or contracts to accomplish some of the research and analysis identified above, also, compensation for damages caused by computer-based information systems/ data banks, etc. College scholar-ships awarded in the relevant areas.
Law and Regulations	Legislation on the security/privacy issue and perhaps on patents and copyrights; court decisions reflect-ing the aforementioned legislation; licenses where appropriate for computer data bank operations; mandatory standards probably at several levels for the security and privacy issue; inspection require-ments for certification of proper security/privacy of ADP based information systems; fines and punitive damages when privacy/ security has been violated or other damages caused by computer-based systems; registration and mandatory reporting of computer-based informa-tion systems/data banks containing sensitive/private information.
Education and Indoctrination	Large-scale educational program to communicate proper background for computer concepts and computer usage; conferences and symposia to assist in communication of relevant information for advanced applica-tions; public (e.g., Congressional) hearings to produce background for legislation and public dissemination of information.

(k) consumer protection

(l) economic growth

(m) criminal justice

(n) urban transportation

(o) population growth (carefully planned program in anticipation thereof)

It can be seen by inspection that Exhibits 27 and 28 can be used to assist in evaluation. The professions, users (or communities of users), and applications listed in these tables certainly would be involved in striving toward achievement of national goals. These tables should be compared with Exhibits 23 and 24 to illustrate the potential difference after the appropriate action options and research and development programs have been implemented. It might appear that this is the "before and after" picture, but that is not quite the case. Exhibits 27 and 28 should be thought of more as describing long range goals. At any given time, the extent to which progress has been made from the situation described by Exhibits 23 and 24 in the direction of that described by Exhibits 27 and 28 is an overall qualitative measure of the effectiveness of the action options and the R & D program that has been implemented. It must be remembered that these are highly aggregated, qualitative characteristics that should be divided into more quantified measures and submeasures. Some of the measures expressed in Chapter IV under the heading, Microlevel Impacts, are appropriate. In addition, various questionnaires, polls, and samplings of the user categories expressed in these tables would be designed, utilized, and evaluated. This information would indicate the degree to which the innovative technology had been productive or, if certain problems occurred, counterproductive during a specific year (or any particular time frame).

EXHIBIT 27
IMPACT PARAMETERS OF COMPUTER TECHNOLOGY WITH RESPECT TO APPROPRIATE USER CLASSES -- WITH ACTION OPTIONS IMPLEMENTED*

APPLICATION CLASSES / IMPACT PARAMETERS	DECISION MAKER DECISION MAKING	POLICY SCIENCES/ ANALYSIS SYSTEMS ANALYSIS	PROFESSIONS - MEDICAL, LEGAL, EDUCATIONAL	AVERAGE CITIZEN
Likelihood of specified impact	Highly likely	Highly likely	Highly likely	Highly likely
Lag time after technology development	Between initial and full applications time-frame	Between technological "perfection" and initial application time-frame	Between initial application and full application time-frame	Approximately full application time-frame
Impact direction - favorable, or unfavorable	Favorable	Favorable	Favorable	Favorable
Controllability of impact	High if planned for from the beginning	High if planned for from the beginning	High if planned for from the beginning	High if planned for from the beginning
Magnitude - slight or great	Potentially great in the favorable direction	Potentially great in the favorable direction	Potentially great in the favorable direction	Substantial in the favorable direction
Duration of impact	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good	1980-85 and beyond if evaluation and acceptance is good

*Exhibits 27 and 28 are presented for comparison or contrast with Exhibits 23 and 24. Taken together they give a preliminary illustration of the situation before and after public action options are implemented. These four tables also illustrate the general commonality of obstacles and impacts across application classes and user groups. There are, however, differences in the details which would become evident when specific studies are performed.

EXHIBIT 28
THE RELATIONSHIP BETWEEN INSTITUTIONAL FACTORS AND RELEVANT APPLICATION CLASSES -- WITH ACTION OPTIONS IMPLEMENTED*

INSTITUTIONAL OBSTACLES \ APPLICATION CLASSES	DECISION MAKER DECISION MAKING	POLICY SCIENCES/ ANALYSIS SYSTEMS ANALYSIS	PROFESSIONS-MEDICAL, LEGAL, EDUCATIONAL	AVERAGE CITIZEN
Political	Greatly reduced	Greatly reduced	Greatly reduced	When applicable - minimal
Legal	Minimal	Minimal	Minimal	Minimal
Administrative/ Organizational	Under control	Function of specific application and manageable	Under control	Function of education
Social/phychological inertia and custom/ tradition	Function of cultural acceptance	Minimal	Function of organization and cultural acceptance	Significant reduction

*Exhibits 27 and 28 are presented for comparison or contrast with Exhibits 23 and 24. Taken together they give a preliminary illustration of the situation before and after public action options are implemented. These four tables also illustrate the general commonality of obstacles and impacts across application classes and user groups. There are, however, differences in the details which would become evident when specific studies are performed.

Some examples of specific items of information for this evaluation are as follows:

(a) the amount of money saved for important additional national goals achieved through better decision-making and policy analysis at the federal government level achieved at least partially through the assistance of computer-based information processing networks (For example, Exhibit 29 illustrates a projection of what the federal government might spend over a decade for social-need projects. If there is a saving of only 10 percent, this would be 160 billion dollars which could be reallocated to critical areas in these programs.)

(b) the amount of information which the professional person and the average citizen has absorbed as a result of the education program included in the action options and R & D effort (One of the significant problems with respect to understanding and misunderstanding the computer is the comparison with the human brain, the popular jargon or "giant brain" syndrome. The following quotation illustrates this:)

> 'Thinking' Machines
>
> A large percentage of computer experts have recognized the limitations of restricting the use of the computer to mathematical optimizing techniques. They have proposed programming the computer like a human brain. Such artificial intelligence would draw inferences, learn from mistakes, and search associative memories for suitable parallel situations, just as a good manager does. The startling early successes in this field led to great expectations and many attempts to implement the potentialities.
>
> In the fascinating RAND Corporation memorandum entitled Alchemy and Artificial Intelligence, Hubert Dreyfus has made a thorough study of these attempts. He surveys efforts to move beyond the very promising beginnings in chess playing, theorem proving, translation, and musical composition, and shows that even in these simplified environments there has been no significant progress. He likens our expectations,

EXHIBIT 29
DURING THE NEXT TEN YEARS THE FEDERAL GOVERNMENT WILL SPEND FOR SOCIAL-NEED PROJECTS*

PROJECT	EXPENDITURE IN BILLIONS
Agricultural research	$ 2.0
Highways	50.0
Mass transit	15.0
Transportation services	20.0
Education	300.0
Health	450.0
Welfare	700.0
Urban redevelopment	60.0
Water and power	50.0
Retraining	19.0
Total more than $1.6 trillion	

*This projection is presented for illustrative purposes only. The projected data in the table was obtained from the cited source and is one forecast among a possible spectrum of predictions.

Source: M. J. Certron, "A Method for Integrating Goals and Technological Forecasts into Planning," Technological Forecasting and Social Change, Volume 2, Number 1, 1970, p. 44. Original source: "Long-Range Planning Study, "Marketing Magazine, July 15, 1967, p. 15, Douglas Aircraft Missiles and Space Systems Division.

based on early successes that we could get computers to think creatively, to the claim that the first man who climbed a tree had achieved tangible progress toward reaching the moon.

Dreyfus concludes that digital computers cannot replicate such essential aspects of human thought as fringe consciousness (an awareness of cues in the environment which are too numerous to be considered explicitly), as what he calls "essence-accident discrimination" (an ability to sort out the necessary from the incidental characteristics), and as ambiguity tolerance (a willingness to deal with variables that are not precisely defined but are useful to the problems at hand). Yet these attributes are essential for managerial decision making.(60)

The degree to which a survey or poll shows an understanding of this matter would be another evaluation indicating progress and success for the program. The relevant professional societies such as AMA, ABA, NEA, ORSA, and TIMS could be of considerable assistance in collecting data as well as promoting educational programs.

(c) "Recently, computer experts from the RAND Corporation, Santa Monica, and the University of California at Los Angeles, in a private exercise, formed themselves into offensive (cheating) and defensive (detecting) teams to test the possiblity of cheating and detecting cheating in the counting of votes in computerized systems. In all tests the offensive or cheating teams were able to win."(61) Such procedures could be used to test progress on security/privacy research development and policy. It also indicates a specific problem area, namely, election rigging which would probably be examined on a high-priority basis.

The evaluation program itself would be worked out in detail first, and progress would be explicitly recorded and evaluated continually on an annual basis. One of the major points of this evaluation is essentially a continuing reassessment of the technology including evaluation, forecasts, and projections so that improved forecasting methods can be devised. The same is true for impact models using highly interactive feedback systems.

CHAPTER VII

FORECASTS/PROJECTIONS, UNCERTAINTY, AND ANALYSIS OF FUTURE IMPACTS

There are many methods of forecasting technological developments and analyzing probable impacts which might, at least initially, be divided into the following classes:

a. intuitive methods -- including individuals, polls, panels, and the Delphi Technique with its modifications

b. development of scenarios

c. trend extrapolation -- including simple trend extrapolation, curve-fitting with judgment, and envelope curves

d. statistical techniques -- including regression and correlation analysis and precursor events

e. analogies -- including historical and growth analogies

f. modeling -- including gaming-simulation, interindustry input/output analysis, and network methods.

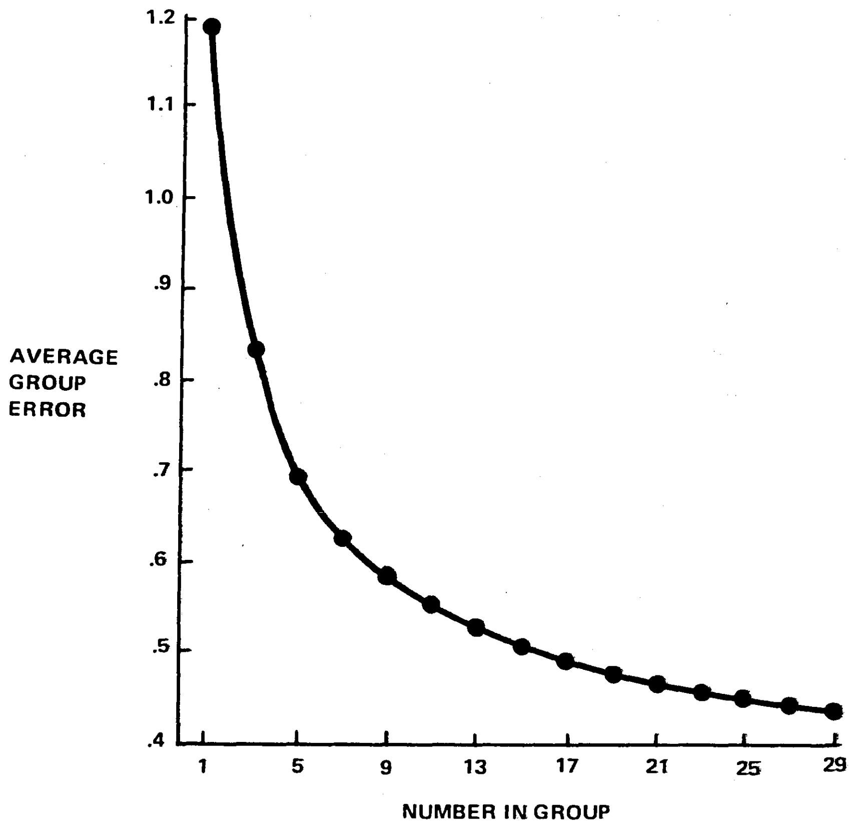
The Delphi technique with modification and the use of scenarios are especially applicable to forecasting computer technology developments. In general, the requirements of any project must be balanced against the resources available. This includes the data bank of information required for the various types of analyses and the availability of analysis tools, e.g., a computer with multiple-access on-line features. There is considerable literature available with respect to most of the techniques; however, the major problem is the integration of the proper techniques with the data bank and facilities available. An important part of the problem is the determination and presentation of the uncertainty associated with the assessment.

DELPHI TYPE TECHNIQUES

The Delphi technique and its modifications are probably extremely useful with respect to these problems. This technique has three major features: anonymity; controlled feedback; and statistical group response. The anonymity is obtained by the use of questionnaires or other formal communication channels, such as on-line computer communication, and is a method for reducing the effect of dominant individuals in the group. The controlled feedback is produced by conducting the analysis in a series of rounds between which a summary of the results of the previous rounds is communicated to the participants. The statistical analysis of the group response is a method of reducing group pressure for conformity and it is possible for a significant spread in individual opinions to exist at the end of the analysis.

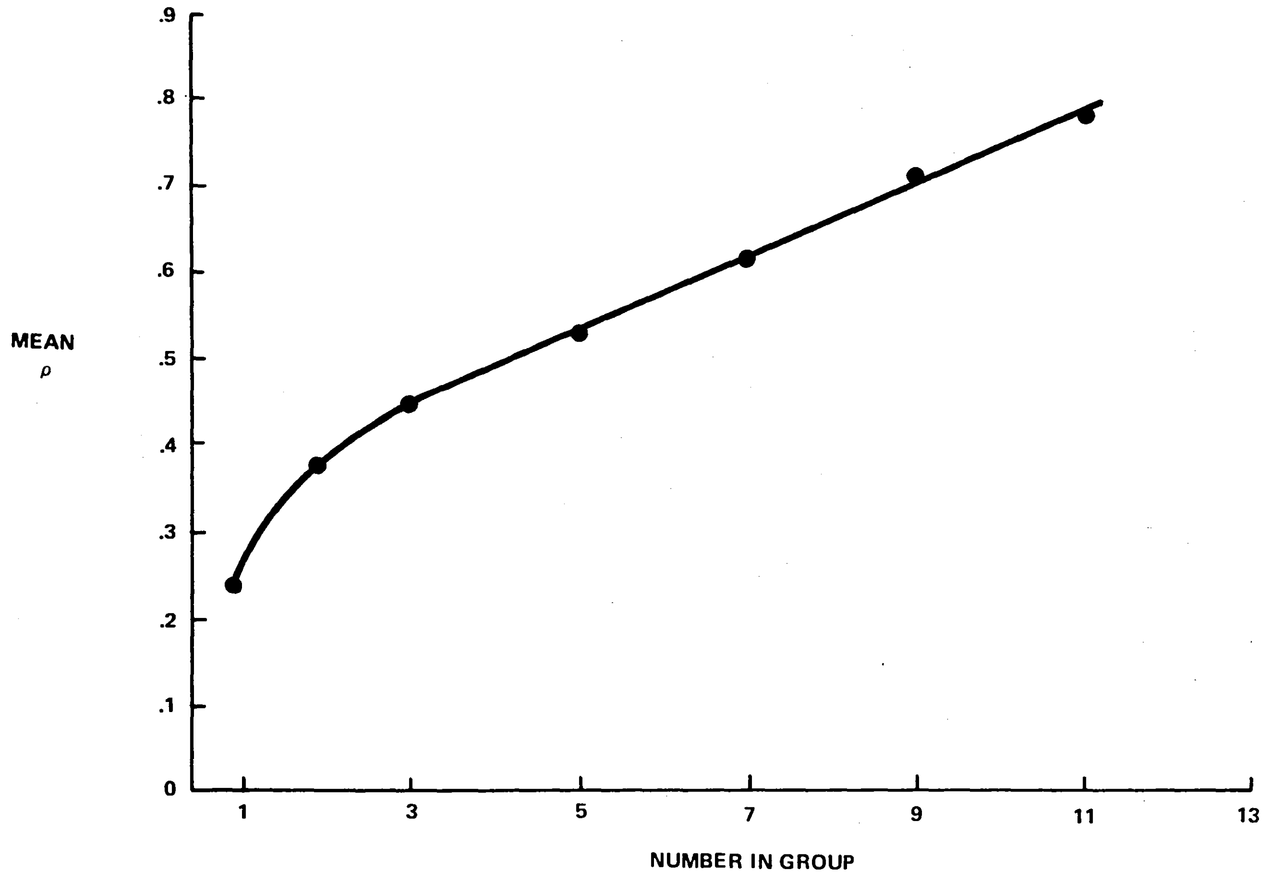
One of the problems that a decision maker faces is the fact that at times he may request advice from experts with apparently equivalent credentials and receive significantly different answers to the same question. A relevant question pertaining to the method, therefore, is whether or not the above problem occurs when using two different groups. According to experiments by the Rand Corporation (Exhibits 30 and 31), average group error and "reliability" of the technique appear to be quite acceptable, with sufficient group size and properly chosen individual participants.[62]

It should be noted that there are now systems for performing on-line Delphi conferences/analyses and one of these systems is operational in the Federal Government in the Office of Emergency Preparedness (OEP). A recent on-line computer meeting experiment conducted by Dr. Murry Turoff of OEP included individuals across the nation who were affiliated with government, industry, nonprofit



Source: Norman C. Dalkey, The Delphi Method: An Experimental Study of Group Opinion, Memorandum RM-5888-PR, The Rand Corporation, June 1969, p. 11.

EXHIBIT 30
EFFECT OF GROUP SIZE



Source: Norman C. Dalky, The Delphi Method: An Experimental Study of Group Opinion, Memorandum RM-5888-PR, The Rand Corporation, June 1969, p. 13.

EXHIBIT 31
RELIABILITY VS. GROUP SIZE

organizations, and universities. Almost half of the individuals involved had no previous experience with computers. The costs incurred during the 13-week experiment were relatively low with the respondents using about 100 hours of terminal time and less than one hour of processing time for a total cost of less than $1,500 if calculated at commercial time-sharing rates.

SCENARIOS

Scenarios can be though of as artificial "case histories." Since there are many possible situations for the future it can be instructive to devise a scenario of what would, or at least could, occur under given circumstances. Development of a scenario requires describing in some detail a hypothetical sequence of events that could lead plausibly to the projected situation. Since the number of possible scenarios of the future is enormous, the productive ones are those which involve a relevant projected problem or future state which presents worthwhile opportunities for the investment of resources.

UNCERTAINITY AND REPRESENTATIVENESS

No matter what technique is used for projecting the future there is significant uncertainty, and a sensitivity analysis with respect to at least a representative set of major assumptions and alternatives should be investigated as far as it is feasible within the constraint of the given resources. It should be emphasized that to be realistic one cannot be exhaustive when dealing with the complex interactions of a future wide-scope technological assessment. One would like, therefore, to be as comprehensive as possible and, most important of all, as representative as possible.

One should, therefore, use the following procedure:

(a) divide the elements under consideration into major classes

(b) choose representatives from these classes (perhaps randomly if appropriate)

(c) perform the analysis with respect to the chosen representative elements

(d) iterate the procedure if resources permit with a separately chosen set

(e) illustrate the sensitivity of the results (conclusion/recommendations, etc.)

(f) in the technological assessment procedure set up a system such that a reassessment can be made either as part of a continuing effort or at intervals such as 1, 3, 5, or 10 years (In this reassessment, a careful analysis of problems vs. progress should be made; any potential problems which might have been put in a "warning system category" or a "monitoring category" should be given special attention during this reassessment.)

Exhibit 32 illustrates the difficulty in attempting to be exhaustive. When one makes certain assumptions/projections with respect to conditions in the future and their various impacts with respect to technological assessment, the following problem arises. Even if one chooses only three values, such as high, average, and low (or 90, 50, and 10 percent) for a particular characteristic or element within a major class of impact categories or constraints, and if ten elements are chosen to represent each area of category (political, economical, sociological, environmental, administrative/political (institutional), demographic, values and life style, and perhaps, the area of projected technology itself) then this produces a total number of combinations which are quite astronomical, approximately equal to 10^{33}, 10^{38}, and, in some cases, perhaps even 10^{48}.

EXHIBIT 32
COMBINATORIAL PROBLEM
VS.
RAW COMPUTER SPEED*

Computer Speed in Operations/Sec \ Number of Combinations	10^{33}	10^{38}	10^{48}
10^{6}	More Than 10^{19} Computer Years	More Than 10^{24} Computer Years	More Than 10^{34} Computer Years
10^{7}	More Than 10^{18} Computer Years	More Than 10^{23} Computer Years	More Than 10^{33} Computer Years
10^{8}	More Than 10^{17} Computer Years	More Than 10^{22} Computer Years	More Than 10^{32} Computer Years
10^{9}	More Than 10^{16} Computer Years	More Than 10^{21} Computer Years	More Than 10^{31} Computer Years
10^{12}	More Than 10^{13} Computer Years	More Than 10^{18} Computer Years	More Than 10^{28} Computer Years

*The computer speed is presented under the quite favorable assumption that a single computer operation produces a result which may actually require a software subroutine, advanced hardware or at least more than one instruction.

The table demonstrates that consideration of this many combinations requires too much time for even the fastest computers extant or projected for the time frame under consideration, 1980 to 1985. Nonetheless, the computer can be used as an assistant with respect to the analysis of comprehensive or, at least, representative presentations. The computer with certain decision rules may reduce the categories to be examined and, if an on-line terminal is used, the analyst can rely on his judgment and intuition to reduce the number of combinations presented and examined.

It should be noted that such techniques as computer simulation/gaming and the use of interindustry input/output analysis can be quite useful in attempting to evaluate the interaction between and among future impacts in a technological assessment.

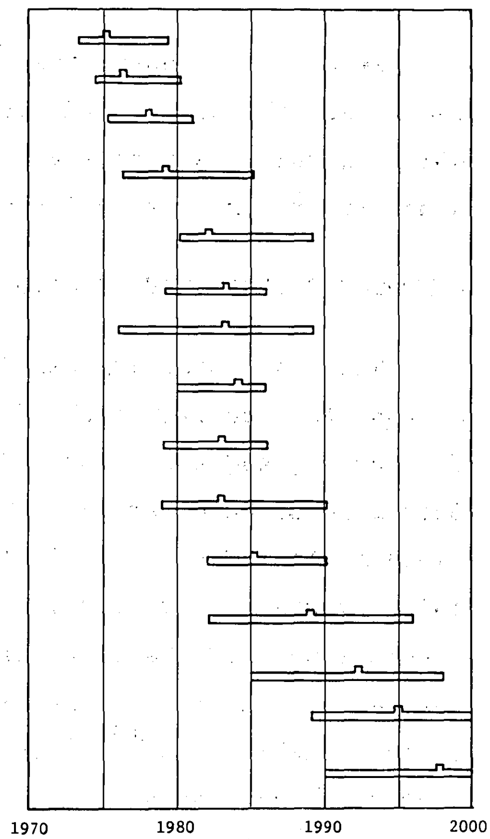
COMPUTER FORECASTS/PROJECTIONS AND FUTURE IMPACT AREAS

With the foregoing discussion as a background, we may now discuss the specific task of the computer technological assessment, forecasting and the future impact evaluation problems. Appendix III, Data Base of Forecasts Pertaining to Development of Computer Technology: Present--Year 2000, illustrates some of the information gathered for this computer pilot study. In Part A of Appendix III, a number of predictions which have appeared in the literature pertaining to future characteristics, applications and impacts of computers are stated. Exhibit 33 [(63)] illustrates some of the projections made in a study which used a form of the Delphi Technique. Part B of Appendix III lists a number of events extracted from <u>A Fifteen Year Forecast of Information-Processing Technology</u>, January 1969, George B. Bernstein.[(64)]

EXHIBIT 33
COMPUTERS AND THE FUTURE

The horizontal bars indicate the interquartile range (where 50% of the responses lay). The vertical bar indicates the median estimate. The last two events had upper quartiles falling later than the year 2000.

1) Direction of large urban traffic flow by computer.
2) Monitoring of patients in major hospitals by computer.
3) Widespread use of Computer Aided Instruction in schools.
4) Computer controlled commercial airplanes including take offs and landings
5) Pocket size computers ("advanced slide rules" with large memory).
6) Recording of scientific and other advances so that constantly updated status is maintained in central files.
7) Computer as diagnostician (giving reliable results).
8) Policing of individual vehicles by combined radar detection and computer record of violations (license number, excessive speed, etc.).
9) Majority of doctors having a terminal for consultation.
10) 50% reduction of labor force in major industries because of automation.
11) Recording of all income by majority of employers on computer terminals and automatic transfer of this information to various tax authorities.
12) Instruction at home through computers.
13) Obsolescence of book libraries as known today for general factual information.
14) Widespread use of automobile autopilots.
15) Computers as common as telephone or television in private homes.



Source: "What Computers May Do Tomorrow," The Futurist, World Future Society, Washington, D. C., October 1969, p. 135.

Exhibit 34 illustrates the format of this information (Appendix III - Part B). Associated with each event are indications with respect to desirability, feasibility, importance, and expected time of occurrence. In the column headed "Goal" is an entry showing whether the event is too minor to be considered a goal (N/A), or whether it is a short-, medium-, or long-range goal (S, M, L). The entries for "Desirability" and "Feasibility" are on an increasing scale from 1 to 9. Under "Timing" the vertices of a triangle indicate when the event would have an estimated probability of occuring of 0.2, 0.5, and 0.9. This report is a result of a technological forecasting project which used a modified Delphi Technique called SEER. Round 1 of that project supplied a preliminary data base of expected future events. Round 2 refined, extended, and structured that data bank to increase its value for planning and analysis. A group of over 45 outstanding individuals in the field of information processing, including representatives from the Federal Government, industry, and the academic world participated in Round 2.

From the various forecasts of computer impacts in the literature the following observations are made:

(a) Many of the forecasts have no date associated with them and one might wonder whether the comments are with respect to the present, near future, or 20 or 100 years from now.

(b) There are conflicts or apparent conflicts in the various forecasts. For example, one forecast might indicate that an event such as large urban traffic flow will be computer-controlled by the mid-1970's. And in contrast, another forecast might indicate that this event would come to fruition but not until the mid-1980's.

(c) In addition, there are many vague statements where the context of the projections is not given. This includes

EXHIBIT 34
COMPUTER ORGANIZATION

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
m.	Special functions within a computer will be implemented in micrologic so that programming will be simplified and maximum efficiency obtained. The micrologic will make use of multiple levels of internal storage, read-only memory, associative memories and yet-to-be developed memory techniques. Phase 1 of this development is here. Phase 2 will see "special purpose" computers (e.g., payroll computer, production control computer, FORTRAN computer) available utilizing completely common hardware.	M	8	5	72–78 (75)
n.	Computer aided logic design will enable the system designer to formulate, evaluate and optimize his proposed design without going through the "breadboard" stage.	S	6	4	68–72 (70)
o.	Parallel organized computers will offer several orders of magnitude speed advantage over conventional computers. This speed advantage will be used to investigate problems too large for conventional computers, in the areas of simulation, automation, hydrodynamics, signal processing, fluid mechanics (weather forecasting), plasma (with applications to the designs of devices for controlled thermonuclear reactions), and a factor of at least 100 compared to the fastest conventional machines presently available. ILLIAC IV represents the first of such systems. ILLIAC IV is scheduled to be operating by mid-1970. Other design philosophies should be thoroughly investigated.	S	8	8	70–75 (72)

Source: George B. Bernstein, A Fifteen-Year Forecast of Information-Processing Technology, AD681-752, Naval Supply Systems Command, Washington, D. C., January 20, 1969, p. 92

problems of definition (semantic problems) and quantification. For example, if an industry or a system is projected to be controlled by computers by a certain date, does this mean 10 percent of this type of system or plant will be computer-controlled, or does it mean 50 percent, or perhaps the largest 30 percent of the plants?

(d) There also are problems of uncertainty which frequently are not alluded to at all in forecasts. When a forecast is made does this mean that the individual making the projection feels that the probability is overwhelming that such an event would occur or is he simply saying that the chances are better than fifty-fifty?

(e) When a date is given, is it the date at which the majority of such applications will use the computer in some manner, or the first feasible date, or is this the date at which some projections will almost certainly come to fruition? Is a particular date the mean time that someone suggests the events will occur with some sort of uncertainty before and after, or is it the latest potential date deemed reasonable?

Some of the differences or conflicts in forecasts are quite real and represent strong differences of opinions among individuals with respect to the technology application. On the other hand, a number of the differences are more apparent than real and can be explained when the semantic problems are solved and when more of the details of some of the questions mentioned above are answered.

Another question which arises is the value judgments that are made with respect to impacts. This is certainly a question of both background and vested interests. There are and will be conflicts among various groups with respect to alleged computer impacts (e.g., the differences of opinion between the data processing and communications industries with respect to the entire issue of computers and communications.)[65] Another illustration might be the problem of computer control and automation. On the one hand, it is desirable to have more efficient industry in order to improve the United States' overall economic situation. But on the other hand, if this advanced automation, which produces the efficient industries that compete with foreign manufacturers, also produces widespread unemployment, then this is a major economic problem for the country. The general view taken in this study is that the overall good of the nation, with due respect to minority groups is the major objective in solving some of these conflicts.

In analyzing some of the projected events which have appeared in the literature, the difference between projected event and directed research towards a specific goal must be recognized. In Exhibit 34, Event "m," it is stated that "Special functions within a computer will be implemented in micrologic so that programming will be simplified and maximum efficiency obtained. The micrologic will make use of multiple levels of internal storage, read-only memory, associative memories and yet-to-be developed memory techniques. Phase 1 of this development is here. Phase 2 will see 'special purpose' computers (e.g., payroll computers, production control computers, FORTRAN computer) available utilizing completely common hardware." According to the exhibit this event will probably take place by the latter half of the 1970's and it is considered rather desirable and at least fairly feasible. However, many so-called software functions, by todays standards, probably should be in more of a hardware form. This would include some of the present and prospective security/privacy software operations and user-oriented software. When such a goal is considered as desirable, and additional actions, such as allocating resources for R & D, are focused on this objective, then the occurrence of the event becomes more probable. Feasibility and desirability become more measurable, if one uses the amount of resources invested in attempting to obtain the goal as a measure.

Applying the technology assessment methodology being developed in this project includes integrating projections which are made in varying depth, some with significant support, others with perhaps a single expert's opinion. The methodology used is essentially first to look for general consistency among knowledgeable forecasters who themselves may be using quantitative means such as multiple regression analysis or trend extrapolation as inputs to their forecasts. Second, examine the data bank with respect to specific relevant events and their reasonableness. For example, the increase in speed of computers might be checked against the work of Graham as represented in <u>The Impact of Future Developments in Computer Technology</u>.[66]

In order that continued progress be made within the computer field there must be exogenous forces impacting in such a manner that the necessary research, development, testing, production, and implementation are continued at a healthy pace. In order to judge the effect of such forces one must examine the catalysts and requirements of the last decade or more with respect to computers, project these elements, and then come to rational conclusions. Some of the basic research and development leading to increased performance (speed and size) was promoted by the AEC and the intelligence and defense communities. A considerable amount of the research and development leading to decreased size, decreased weight, increased reliability, and ruggedness was promoted by the missile and space programs. The increase in performance and reliability and the interaction of communications with computers was sponsored to a significant measure by military funding. In addition, the competitive force of the open market place has provided impetus for commercial machines.

In the future, the intelligence, command and control, and communications communities will have a continuing need for improved systems;

the missile and space programs, although modified somewhat recently, will continue to support advanced computer techniques. (Indeed, if computers replace certain functions for an extensive unmanned, rather than manned space program, there should be even more emphasis on advanced computer development.) The AEC will continue to use large computer systems to perform sophisticated simulation and run mathematical models. In the commercial market place there will be an increasing requirement for computer-based information networks because of the following commerical, economic, and social forces;

(a) need for speedy information in order to survive

(b) need to stay competitive

(c) need to avoid being overwhelmed by the information and paper "explosion"

(d) intellectual amplification

In order that the various national programs, especially those oriented towards our internal problems, can be analyzed from a cost/benefit point of view, significant amounts of data must be gathered, analyzed, sorted, disseminated, and displayed in a timely and reliable manner.

Integrating all those factors, one can make a strong affirmative projection regarding the development of computer-based information networks as described in Chapter I.

However, no matter what technique is used it must be remembered that the resources for not only this pilot study, but even for longer investigations are finite and constrained. It is, therefore, strongly recommended that technological assessment studies set up a feedback process for reassessing the technology. This will permit the dynamic nature of all the impacts including economical, political, societal, environmental, managemental, etc., to be integrated in a system in a manner similar to Forrester's work in Industrial Dynamics and Urban Dynamics. Such a feedback system would help to evaluate whatever method was used for projections and forecasts as well as assist in structuring the overall problem for the decision maker.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

From the study described herein, various conclusions and recommendations may be stated. It should be pointed out, however, that the conclusions and recommendations are somewhat general and that the projections represent impact directions and performance envelopes rather than specific numbers. This is mainly due to the qualitative and approximate nature of the analysis, the fact that this was only a six man-month study, and to the caveats mentioned in the Foreword.

CONCLUSIONS

Although there is uncertainty due to the conditions described above, and many of the statements must reflect judgments rather than detailed analysis, the following conclusions are made:

(a) During the research and analysis performed for this study, it was soon realized that, although there are many individual impact forecasts for the technology, it would be quite presumptuous to state some of these predictions and speculations, then proceed to use them as the basis for positive-sounding or definitive statements about the future including a final impact forecast. This conclusion was reached through the analysis of the literature and through interaction and discussions with reviewers. On the other hand, there is sufficient evidence from this preliminary analysis to warrant the conclusion that a plan for organizing action options including a research, development and monitoring program and legislation and educational programs should be devised at the earliest time feasible.

(b) Computers probably have had as great an impact on our society as any other technical innovation of the past quarter century. In the future, computers and communications will have an even more salient impact on our society and in a major way will affect such areas as economics (one projection from the literature is a market of $260 billion cumulative 1970-80), values, goals, and priorities, the social issues; and institutional, political, legal and demographic areas. The importance of the interaction of computers and communications forming networks is further illustrated by the following projections which were referenced in this report: an increase by a factor of 200 in the total number of computers coupled with communications in the decade of the 1970s; and that by 1974 between one and two million terminals will be linked to computers.

(c) The impact of societal conditions upon computer technology and its advancement produces a set of constraints. In many cases, these impacts will operate in both directions in an iterative manner, i.e., a particular societal condition may impede or accelerate the growth of technology and its application, and then in turn, be impacted upon by the innovative technology. This can produce a highly dynamic situation which will modify any initially rather static conditions. It is certainly not always intuitively obvious what the "steady-state" condition will be.

(d) The key to the technology assessment of computers is the realization that the computer is essentially the "forcing function" or "dynamo" that drives the computer-based network, and that it is the information and its analysis which are of fundamental importance for policy-making and implementation; and use by the medical, legal and educational professions. This means that the projected advances in computers-communications will present major innovative tools for society but that the measure of the computer impact will really be the changed nature of performance, in the cost/benefit sense, for the various professions, and the changed nature of the life style and quality of life of the individual citizens. This change would present at least some measure of the impact of the security/privacy issue. It should also be pointed out that the impacts noted here are a representative set from a much larger list of impacts, both good and bad.

(e) The projected advances in the technologies will permit systems that will be capable of handling up to tens of thousands of on-line devices, depending upon the overall systems design and the function of individual on-line elements. By 1980-85 there should also be significant advances in computer program systems dedicated to particular professions such as law, medicine, education and policy analysis. The advances in computers and communications projected for the 1980-85 time-frame will also permit the design and efficient implementation of distributed computer-based information networks and data banks. As a result of all these projected advances, a significant increase in the quality and quantity of health service, education and administration of justice per resource expended should be possible. On the other hand, if sufficient attention to problems such as security and privacy is not forthcoming, then these same advances can potentially change the character of our life style and the quality of life in a very profound and unfavorable manner.

(f) Even with extremely powerful computing systems, it is still very difficult to perform comprehensive analyses when one is considering a technology such as computers, which has major interacting impacts upon virtually all of the various societal conditions. The total number of combinations of possible interactions becomes too astronomically large for even comprehensive quantitative analysis. Probably the best approach would include analysis of statistically random representative samples of interactions. The computer can certainly be of major assistance in this latter task. If the analyst has an on-line terminal, then he can use his judgment, intuition, and education to assist in limiting the number of choices and in changing the direction of a specific investigation of these interactions. This man-machine combination should be the optimum approach in attacking such problems.

RECOMMENDATIONS

Although no one can predict the details with complete accuracy, there really can be very little doubt that computer technology will continue to have a growing impact on many aspects of our society. For this reason it seems imperative that national policy be formulated and implemented to guide the development and control the impacts of computer technology in directions most beneficial to our society. In view of this, the following recommendations are made:

(a) A nucleus planning and analysis group should be formed on a permanent basis for the technological assessment of computers and their variety of complex impacts. This group would be the focal point and pivotal element for a continuing research, development and monitoring program in this area.

It would conduct and integrate the planning and analysis of specific long-range programs which would be necessary before more detailed definitive statements on computers-communications technology and impacts can be supported. This is true because the technology assessment of computers is not a one-time process, but takes considerable time and effort to produce an organized, coordinated on-going program. There are many individual efforts today, and some of the items and other recommendations that follow may already be under investigation by appropriate agencies of the government, but there is a significant need for the ordering of priorities which is an extremely difficult problem and can only be rationally attempted through the "systems approach" rather than any piecemeal effort. The allocation of resources for these various efforts again should be a coordinated, well-planned and implemented program. Further, only a sustained technological assessment program for computers-communications could collect and analyze the large volumes of relevant information in this highly dynamic field. Finally, it should be pointed out that legislative programs, large educational programs, large-scale experiments, and substantial R & D efforts are all long-term endeavors and, for real, substantial, coordinated results, a permanent organization is required. Many government organizations will probably be involved in this effort. Some of the additional tasks which should be performed under the guidance and direction of this group are listed in the other recommendations.

(b) Some of the classified military areas should be examined with appropriate security safeguards. The reasons for this recommendation are: to complete the picture of current and projected state of the art; to obtain any additional spillovers that might be useful in the security/privacy area; and to obtain a high level objective review of the impacts of the advanced developments in computers-communications including potential problem areas such as the complete computer program debugging problem of the ABM.

(c) An in-depth investigation of the computer's impact on employment should be performed. This investigation would include a monitoring system for the employment-unemployment situation and automation. On the one hand, some forecasts indicate that between one and two million workers will be employed in the computer-information industry by approximately 1975; on the other hand, other projections indicate that in the decade of the 1980's, significant automation may reduce the labor force in present industry by 50 percent and, in addition, some forecast automation impacting upon the computer industry itself with automatic devices replacing certain data collection and data input jobs. Since the situation is far from clear, there is a need for such a monitoring system which would enable policy analysis and decision-making as part of the necessary anticipatory planning which would be relevant to the situation. Two of the organizations that historically have been concerned with these matters are the Labor and Commerce Departments.

(d) Solutions, both technical and legal, must be found and implemented to lessen the problems of security and privacy of computer-based information systems, networks, and data banks in order that overall policy may be formulated soon. The security/privacy problem can be controlled adequately if proper legislation and policy decisions are implemented and the problem is considered in the initial planning stages of a computer-based system. Solutions would include: encryption, decoupling of the general users such as doctors or educators from the inner workings of the system, and relevant investigation of the various system personnel. In addition, some of the specific legislation (to require holders of data banks to inform citizens of information held and permit the citizens to examine and correct information; to authorize the investigation of sensitive personnel; and permit injured individuals to redress their grievances through court action with appropriate penalties attached) should be enacted.

Specific consideration should be given to forming what might be called "Devil's Advocate" or "Break-In" teams which would consist of knowledgeable individuals who would deliberately attempt to break the system's security and protection provisions, in order to substantially test and certify a system. These groups would be relatively independent and certainly would be rewarded for success in their endeavors. Feedback information from these groups would be used to further tighten security and protect the system, as well as assist in decisions relevant to the certification of a system.

In order to assist in dispersing the semantic fog around the area of security and privacy, the terms security (really referring to defense information), privacy (the right of an individual to keep certain information to himself), confidentiality (the protection of privileged communication by both law and policy--this is not to be confused with the defense security classification of confidential), and protection from destruction (by such means as bombing, burning, or electro-magnetic destruction through erasure, etc.) should be clearly defined and analyzed. Where there is a body of law cases/precedents, etc., this should be gathered in data banks and clearly presented to both system users and implementers.

(e) The copyright and patent problems for computer-based information systems should be the subject of further investigations--both legal and technical. This is necessary to further the exchange and reproduction of information by the most modern computer-based techniques while simultaneously giving credit and remuneration to the creative efforts of authors and inventors. Some of this effort may be currently underway, in which case it could be reviewed and integrated into the overall program.

(f) Large-scale experiments in application of computers should be performed through the interaction of information technology organizations/agencies and mission-oriented organizations/agencies. These experiments should produce relevent information in regard to the direction of further developments in computer technology both from the point of view of policy and science. In addition, such experiments would demonstrate the usefulness of computers-communications technology in the many other areas of our society. Data from these experiments should be extremely fruitful for the program planning and budgeting systems, and perhaps for future legislation.

(g) A plan for a strong educational program for both the applications of computers and their fundamental concepts for all age groups should be devised. Such a strong educational program would assist in expediting applications that will benefit our entire society, and a better informed citizenry will be in a much better position to protect their rights in regard to such issues as security/privacy.

(h) The specific organizational and policy implementation problems of the control and guidance of computer-based impacts should be addressed. What has sometimes been referred to as the "computer problem" is not really a single problem but a spectrum of present and potential problems and present and potential opportunities for major benefits.

(i) A large-scale directed R & D program should be established. The following list includes many of the objectives of such a program. The desired advances indicated in this list are from the point of view of service to the user or consumer rather than particular hardware advances which may be part of on-going R & D effort of the various computer vendors. Breakthroughs and directed research and development which would be instrumental for achieving effective man-machine interaction and "information networks" are:

(1) voice input, at least to a limited extent and at nonprohibitive cost to the user

(2) relatively inexpensive sophisticated terminals/minicomputers

(3) improved capability for verification and subsequent official certification of software performance (This research and analysis is directed to attacking the problem of "debugging completely", or at least with some ac acceptable certification, large complex software systems)

(4) increased acceptance on the psychological and political level of the most innovative technology

(5) decrease in the cost of software development

(6) decrease in the cost of reliable, multiple-font optical character readers

(7) practical and economically viable solution to the security/privacy problem

(8) advances in user-oriented modeling/simulation and basic understanding of some of the relationships in the complex "real world"

(9) performance standards and measures for hardware and software

(10) advances in methods for educating programmers for performance on advanced systems

(11) progress towards higher efficiency in the implementation of the highest level user-oriented computer languages/systems (These languages/systems are close to the non-professional programmer user and, although simple to use, may cause significant complexity and possible inefficiencies from the point of view of the internal system.)

(j) Both a computer-based network or subnetwork and a major data bank should be implemented for the purposes of technological assessment in general and specifically for the purpose of a technological assessment of computers-communications and their complex impacts. In order to expedite the formation of a data bank, it could be initially in manual form with the conversion to computerized form at the earliest feasible time. Some of the components of such a network could be implemented almost immediately while others would come to fruition during the next decade. Such a computer-based assistance for technological assessment could reduce the time for information retrieval by perhaps a factor of two and in some cases by two orders of magnitude. Since technological assessment studies may very well be performed under tremendous time stress because of imminent policy decisions, this should be a major benefit. The inclusion of a computer-assisted text editing system should reduce the time requirements for the production of interim or draft reports and their review and evaluation. The computers-communications system could perhaps also then be used for mathematical modeling, interindustry input/output analysis, multiple regression analysis, dynamic feedback models perhaps using DYNAMO, and such techniques as the on-line Delphi method. There is a significant requirement for a major data bank with respect to technological assessment which should contain case histories, general background, and results of analyses in order to facilitate inclusion of technological assessment in the policy analysis and decision-making processes. The data bank should also include appropriate information with respect to our national environment broken down into various categories including economical, societal, environmental, political, etc. This information would be quantified wherever feasible, indexed and abstracted as appropriate, and would include projections and forecasts and their associated uncertainties. A specific directed Delphi type analysis should be performed to produce additional information and update present data. As soon as feasible, this technique and analysis should be implemented with an on-line system. This system would be useful for both technology assessment in general and specifically for the technology assessment of computers.

(k) There should be further research and analysis to refine methodology for cost-performance (cost-effectiveness and cost-benefits) analysis for the complex computer network systems under consideration. This would include attempts to give more precise answers to such questions as the following:

(1) When to compute locally versus transmitting information on communications networks to a more central location.

(2) When to use electro-magnetic communications versus the transportation system: automobile, plane, mail service, etc.

(3) What an "optimum" or at least "near optimum" configuration might be when examined in the cost benefit/effectiveness/performance sense, and especially considering customers' or consumers' demands and requirements.

This research and analysis would be an action option directed to the problem of faulty cost-benefit/performance projections, which in the past have resulted in scandalous cost overruns and lack of performance in the eyes of the user (customer or consumer). Much adverse publicity which has damaged the image of computer-based systems has been caused by this problem.

Hugh V. O'Neill

Hugh V. O'Neill

APPENDIX I

GLOSSARY AND LIST OF ACRONYMS

The relatively few professionals already working in the technology assessment field seem to agree that because the process of applying technology in our pluralistic society is so widely diffused, it is important that knowledge about the mechanics of making a technology assessment be widely disseminated. Therefore, this report is intended for a widely diverse group of readers. They include:

(a) high level government personnel (management and technical)

(b) similar level personnel in state and local governments, business corporations, and various public service organizations

(c) journalists and writers associated with scientific publications -- Scientific American, Science, etc.; science editors for the New York Times, Christian Science Monitor, Fortune, etc.

(d) specialists in various disciplines (engineers, scientists, economists, sociologists, etc.) who have little prior acquaintance with the technology assessment movement and who have had only peripheral contact with the "systems" approach

(e) college level students studying environmental problems

(f) concerned citizens who are interested in learning more about the analytical process of relating technology to other sectors of society

The main body of this report on the Computer Pilot Study was written with the above audience in mind; voluminous, supporting, technical details were relegated to appendices. Nonetheless, it was found to be virtually impossible to exclude completely from the text some of the jargon of the computer field. It seems to be one of the facts of life in the environment of research and development of a new technology that previously existing vocabularies are found to be inadequate for concise and accurate communication of ideas. New terminology and special meanings for old words are established. In time, of course, much of the jargon is absorbed by that part of the language which enjoys general usage by many segments of the population (e.g., nuclear reactor). However, at this point in time much of the terminology associated with computers is understood only by specialists in the field. Indeed, there is not universal agreement among professionals in the field as to the meaning of some of the terms. A glossary and list of acronyms has been included, therefore, to facilitate common understanding of the ideas expressed in this report. Most of the definitions were taken from American National Standard Vocabulary for Information Processing.[67] The definitions in this Appendix which are preceded by an asterisk are these terms. The symbol "(SC1)" at the beginning of a definition is used to identify definitions that have been discussed and agreed upon at meetings of the International Organization for Standardization Technical Committee 97/Subcommittee 1.

GLOSSARY

*analog: (SC1) Pertaining to representation by means of continuously variable physical quantities. (Contrast with "digital".)

*analog computer: (1) (SC1) A computer in which analog representation of data is mainly used. (2) A computer that operates on analog data by performing physical processes on these data. (Contrast with "digital computer".)

*automation: The investigation, design, development, and application of methods of rendering processes automatic, self-moving, or self-controlling.

*binary: (1) Pertaining to a characteristic or property involving a selection, choice, or condition in which there are two possibilities. (2) Pertaining to the number representation system with a radix of two.

*binary digit: In binary notation, either of the characters, 0 or 1. Abbreviated bit.

*binary notation: Fixed radix notation where the radix is two. For example, in binary notation the numeral 110.01 represents the number 1 x 2 squared plus 1 x 2 to the first power plus 1 x 2 to the minus 2 power, that is, six and a quarter.

*bit: A binary digit.

*bit string: A string of binary digits in which the position of each binary digit is considered as an independent unit.

*central processing unit: (SC1) A unit of a computer that includes the circuits controlling the interpretation and execution of instructions. Synonymous with main frame. Abbreviated CPU.

*computer: (SC1) A data processor that can perform substantial computation, including numerous arithmetic or logic operations, without intervention by a human operator during the run.

computer-based information processing system: Pertaining to a system that includes both information collection, storing and dissemination; and computation, simulation and modeling based upon appropriate data.

computer-based information network: A system including such features as time-sharing; on-line multiple access; real-time, man-machine interaction; remote access; computer networks; networks of computers; and data banks, both private and public. (See individual definitions of terms.)

computer network: Pertaining to a computer with various remote terminals, devices, and the associated communication circuits.

*computer word: A sequence of bits or characters treated as a unit and capable of being stored in one computer location. (Synonymous with "machine word".)

*cybernetics: (SC1) That branch of learning which brings together theories and studies on communication and control in living organisms and machines.

*data bank: A comprehensive collection of libraries of data. For example, one line of an invoice may form an item, a complete invoice may form a record, a complete set of such records may form a file, the collection of inventory control files may form a library, and the libraries used by an organization are known as its data bank.

data base: (See "data bank".)

*digit: A symbol that represents one of the non-negative integers smaller than the radix. For example, in decimal notation, a digit is one of the characters from 0 to 9. (Synonymous with "numeric character".)

*digital: (1) (SC1) Pertaining to data in the form of digits. (2) Contrast with analog.

*digital computer: (1) (SC1) A computer in which discrete representation of data is mainly used. (2) A computer that operates on discrete data by performing arithmetic and logic processes on these data. Contrast with analog computer.

display device: Pertaining to a device that offers visual presentation of data.

full application: This means that the technological innovation has been accepted by a substantial number of potential users, perhaps greater than 50% or maybe an even larger percentage. It also means that some of the institutional barriers with respect to social, political, psychological inertia have been overcome and that the cost-effectiveness, reliability, and general operational performance are in a fairly substantial state of advanced operational, user-oriented development.

*general purpose computer: (SC1) A computer that is designed to handle a wide variety of problems.

*hardware: (SC1) Physical equipment, as opposed to the computer program or method of use, e.g., mechanical, magnetic, electrical, or electronic devices. Contrast with software.

*hybrid computer: (SC1) A computer for data processing using both analog representation and discrete representation of data.

initial application: This means that the particular technological advance or innovation is being used by at least a small percentage of the potential market in an operational sense and that the technology is a step beyond the technological perfection stage. This step beyond may be in terms of acceptance of the innovation as well as the advances in technology "reliability".

*interleave: To arrange parts of one sequence of things or events so that they alternate with parts of one or more other sequences of things or events and so that each sequence retains its identity, e.g., to organize storage into banks with independent busses so that sequential data references may be overlapped in a given period of time.

man-machine interaction: The interaction involved in the method of utilizing a computer whereby the user, by means of an on-line terminal/mini-computer, performs an input action which causes the computer to perform a sequence of operations and provide an output to the user. The user then, depending on the output, can perform another input action. The interaction continues in an iterative symbiotic manner.

mini-computer (sophisticated terminal, intelligent terminal, sophisticated electronic desk calculator): The capability of this class of devices is a function of the time-frame under consideration, i.e., a mini-computer or sophisticated terminal of the 1980 to 1985 time-frame would be capable of performance of the order of magnitude of medium to larger computers of the 1965 to 1970 time frame. The prefix mini is a relative term with respect to physical size (volume), cost and performance relative to the state-of-the-art of a particular time-frame. The device in question, whether called mini-computer, sophisticated terminal or intelligent terminal, in the 1980 to 1985 time-frame should be capable of the following: internal stored program; ordinary arithmetic operations, probably including floating point and elementary mathematical and statistical calculations; performing a certain level of encryption when appropriate; control of fairly sophisticated input/output audio visual displays, etc.; checking more sophisticated programs for at least the more obvious compiler/language errors before the more sophisticated programs are sent to the central shared computer-based information processing network system.

network of computers: A network with the major nodes themselves consisting of computers and ancillary equipment, interconnected by appropriate data links.

on-line: (1) Pertaining to equipment or devices under direct control of the central processing unit. (2) Pertaining to a user's ability to interact with a computer.

on-line multiple access: Pertaining to access to a computer by a number of users in such a way as to interact with the computer, that is, an input action by a user would cause the computer to perform one or more operations and provide an output to the user, who would then provide another input to the computer. Usually the computer is operated in a time-shared mode for this type of service. (See "computer network".)

*real time: (1) Pertaining to the actual time during which a physical process transpires. (2) Pertaining to the performance of a computation during the actual time that the related physical process transpires, in order that results of the computation can be used in guiding the physical process.

*remote access: Pertaining to communication with a data processing facility by one or more stations that are distant from that facility.

*software: (SC1) A set of computer programs, procedures, and possibly associated documentation concerned with the operation of a data processing system, e.g., compilers, library routines, manuals, circuit diagrams. Contrast with hardware.

sophisticated electronic desk calculator: A desk calculator capable of operating from a stored program. (See "mini-computer".)

*special purpose computer: (SC1) A computer that is designed to handle a restricted class of problems.

technological perfection: This is considered to be somewhat similar to "an initial operating capability". It essentially means that the technology has been "perfected" well enough to be used in an initial operational sense perhaps for prototype, proof-testing, pilot operation, and initial trials. It means that the reliability, maintainability and operational performance in a cost/benefit sense are all reasonable but certainly far from "perfect", i.e., beyond the R&D stage and entering into operation.

terminal (intelligent): (See "mini-computer".)

terminal (sophisticated): (See "mini-computer".)

*time sharing: Pertaining to the interleaved use of the time of a device.

time sharing: Participation in available computer time by multiple users, via terminals. Characteristically, the response time is such that the computer seems dedicated to each user.

*word: (1) A character string or a bit string considered as an entity. (See "computer word".)

LIST OF ACRYONYMS

ACRONYM	DEFINITION
AEC	Atomic Energy Commission
AFIPS	American Federation of Information Processing Societies
AMA	American Medical Association
AMACUS	Automated Microfilm Aperture Card Updating System
ARPA	Advanced Research Project Agency
AT&T	American Telephone and Telegraph
BIS	Business Information System
CAI	Computer Aided Instruction
CATV	Community Antenna TV, Cable TV
CDC	Control Data Corporation
CIM	Computer Input Microfilm
COBOL	Common Business Oriented Language, a computer programming language
COCI	Communications-Oriented Computer Installations
COM	Computer Output Microfilm
COSATI	Committee on Science and Technological Information
CRT	Cathode Ray Tube
CSC	Computer Sciences Corporation
DoD	Department of Defense
DELPHI	Intuitive Forecasting Technique Developed by The RAND Corporation
DYNAMO	A Software System including a Compiler and Language for Continuous Models Developed for Industrial Dynamics Simulations
EDP	Electronic Data Processing
FCC	Federal Communications Commission
FORTRAN	Formula Translator, a computer programming language
FOSDIC	Film-Optical Sensing Device for Input to Computer

LIST OF ACRONYMS (Concluded)

ACRONYM	DEFINITION
GE	General Electric
GIGO	"garbage in, garbage out"
GNP	Gross National Product
GPSS	General Purpose Systems Simulator
MIRS	Micro Interactive Retrieval System
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NEA	National Education Association
NCIC	National Crime Information Center
NMA	National Microfilm Association
OCR	Optical Character Reader
OEP	Office of Emergency Preparedness
ORSA	Operations Research Society of America
OST	Office of Science and Technology
OTP	Office of Telecommunications Policy
RCA	Radio Corporation of America
RD&M	Research, Development and Monitoring
RDT&E	Research, Development, Testing and Evaluation
SRI	Stanford Research Institute
SST	Supersonic Transport
TIMS	The Institute of Management Sciences
UCC	University Computing Corporation

APPENDIX II

A SAMPLE CATALOG OF COMPUTER APPLICATIONS

Part A is a selected sample from the IBM Submission to the Federal Communications Commission.[68] This indicates some of the data processing applications in the next decade and illustrates the estimated use of common carrier lines. It should be noted that:

(a) Even when the majority of systems will not use common carrier lines for a particular application that, nonetheless, some of the systems including possible important installations may very well use common carrier lines.

(b) Some of the cases where the majority of systems will not use common carrier lines may, nonetheless, use communications systems (dedicated, special-purpose, in-house) for reasons of security/privacy and economics. This IBM Submission might be summarized, in part by the statistics shown in Exhibit 35.

Part B of this appendix consists of a selected sample from the article, "Over 2000 Applications of Computers and Data Processing,"[69] and presents some indication of the breadth of applications and impacts of computers. This article contains more than 2000 applications of computers and is not necessarily an exhaustive or mutually exclusive list. It can be summarized in part by the statistics shown in Exhibit 36.

With respect to this selected sample catalog of computer applications, the following points should be noted:

(a) Even though these lists are quite extensive, nonetheless, the various groups, classes, and subclasses could themselves be divided into further lists of applications.

(b) There are many additional U. S. Government classified and unclassified applications. Indeed, the Federal Government is the largest single user of computers.

(c) The submission by IBM to the FCC was made in 1968 and there will be considerable expansion, especially with respect to the interaction of computers and communications applications in the 1980 to 1985 time frame.

EXHIBIT 35
SUMMARY STATISTICS - DATA PROCESSING APPLICATIONS*
IN THE NEXT DECADE SHOWING ESTIMATED USE OF COMMON CARRIER LINES

COMPUTER APPLICATION CLASS	OPERATIONAL TODAY		NOT GENERALLY OPERATIONAL TODAY		TOTAL NUMBER OF SUBCLASSES WITHIN EACH CLASS
	Majority will not use Common Carrier Lines	Majority will use Common Carrier Lines	Majority will not use Common Carrier Lines	Majority will use Common Carrier Lines	
Retail	6	6	0	3	15
Chain & Wholesale	5	0	1	2	8
Consumer and Package Goods Field	4	1	4	0	9
Education	10	5	3	3	21
Life, Group & Health Insurance	10	4	0	0	14
Property & Liability Insurance	4	4	0	0	8
Savings Institutions	5	3	1	1	10
Investment & Securities Brokerage	10	3	0	0	13
Commercial Banks	7	2	1	7	17
Manufacturing	25	5	6	0	36
Hospitals & Medicine	1	5	6	7	19
Newspapers, Printers & Publishers	13	2	3	0	18

* The figures in the table indicate the number of subclasses within each major application class.

EXHIBIT 35 (Concluded)
SUMMARY STATISTICS - DATA PROCESSING APPLICATIONS*
IN THE NEXT DECADE SHOWING ESTIMATED USE OF COMMON CARRIER LINES

COMPUTER APPLICATION CLASS	OPERATIONAL TODAY		NOT GENERALLY OPERATIONAL TODAY		TOTAL NUMBER OF SUBCLASSES WITHIN EACH CLASS
	Majority will not use Common Carrier Lines	Majority will use Common Carrier Lines	Majority will not use Common Carrier Lines	Majority will use Common Carrier Lines	
Public Utilities	6	8	1	4	19
Telephone Companies	5	6	1	6	18
Petroleum & Industrial Chemical Processing	12	7	2	0	21
State & Local Government	9	10	6	10	35
Agriculture	5	1	0	0	6
Airlines	7	5	6	9	27
Railroads	4	4	6	9	23
Motor Freight	7	7	5	3	22
Federal Government	18	14	0	0	32
Garment & Apparel Industry	10	0	2	0	12

* The figures in the table indicate the number of subclasses within each major application class.

EXHIBIT 36
SUMMARY STATISTICS OF OVER 2000 APPLICATIONS OF COMPUTERS AND DATA PROCESSING

COMPUTER APPLICATION CLASS	NO. OF SUBCLASSES OF APPLICATIONS WITHIN EACH GROUP
I. BUSINESS AND MANUFACTURING IN GENERAL	190
1. Office	114
2. Plant and Production	76
II. BUSINESS -- SPECIFIC FIELDS	942
1. Advertising	13
2. Automotive Industry	22
3. Banking	39
4. Educational and Institutional	52
5. Farming	28
6. Finance	38
7. Government	137
8. Hospitals	48
9. Insurance	43
10. Labor Unions	11
11. Law	20
12. Libraries	12
13. Magazine and Periodical Publishing	16
14. Military	6
15. Oil Industry	73
16. Police	20
17. Public Utilities	53
18. Publishing	9
19. Religious Organizations	5
20. Sports and Entertainment	59

EXHIBIT 36 (Continued)
SUMMARY STATISTICS OF OVER
2000 APPLICATIONS OF COMPUTERS AND DATA PROCESSING

COMPUTER APPLICATION CLASS	NO. OF SUBCLASSES OF APPLICATIONS WITHIN EACH GROUP
III. SCIENCE AND ENGINEERING	793
1. Aeronautics and Space Engineering	111
2. Astronomy	16
3. Biology	23
4. Botany	3
5. Chemical Engineering and Chemistry	36
6. Civil Engineering	82
7. Economics	8
8. Electrical Engineering	32
9. Geology	13
10. Geophysics	7
11. Hydraulic Engineering	28
12. Marine Engineering	32
13. Mathematics	44
14. Mechanical Engineering	34
15. Medicine and Physiology	151
16. Metallurgy	2
17. Meteorology	22
18. Military Engineering	31
19. Naval Engineering	7
20. Nuclear Engineering	17
21. Oceanography	12
22. Photography	8
23. Physics	18

EXHIBIT 36 (Concluded)
SUMMARY STATISTICS OF OVER
2000 APPLICATIONS OF COMPUTERS AND DATA PROCESSING

COMPUTER APPLICATION CLASS	NO. OF SUBCLASSES OF APPLICATIONS WITHIN EACH GROUP
24. Psychology	24
25. Sociology	5
26. Statistics	27
IV. HUMANITIES	96
1. Anthropology	2
2. Archeology	17
3. Art	9
4. Games of Skill	8
5. Genealogy	5
6. Geography	4
7. History	12
8. Languages	14
9. Literature	10
10. Music	15

PART A: A SAMPLE OF THE DATA PROCESSING APPLICATIONS IN THE NEXT DECADE SHOWING ESTIMATED USE OF COMMON CARRIER LINES

Applications followed by an asterisk (*) are not generally operational today, but are anticipated during the next decade. Columns next to the applications provide estimates of the use of common carrier lines by the majority of systems performing each application.

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will: Not Use Common Carrier Lines	Use Common Carrier Lines
RETAIL:		
Payroll	X	
General Ledger	X	
Accounts Receivable	X	
Order Entry & Processing		X
Order Entry to Warehouses*		X
Credit Authorization	X	
Audit of Sales Transactions	X	
Inventory Management	X	
Purchase Order Control		X
Remote Purchasing*		X
Sales Reporting		X
Restaurant Data Collection		X
Management Information System		X
On-Line Sales Reporting*		X
Credit Bureau Reporting		X
EDUCATION:		
Admissions		X
Registration		X
Student Fee Accounting	X	
Housing Records	X	
Testing	X	

	The Majority of Systems Will:	
	Not Use Common Carrier Lines	Use Common Carrier Lines
EDUCATION (Cont.):		
Placement Service		X
Alumni Records	X	
Athletic Ticket Accounting Activities	X	
Fiscal Accounting and Reporting		X
Personnel Records & Services	X	
Maintenance & Operation Scheduling	X	
Classroom Scheduling	X	
Purchasing	X	
Instructional Problem Solving		X
Test Processing*		X
Food Service (menu planning, inventory control, purchasing, etc.)	X	
Lab Equipment Accounting*		X
On-Line Experiment Control*	X	
Computer-Assisted Instruction*	X	
Interlibrary Loans*		X
Document Retrieval*	X	
COMMERCIAL BANKS:		
Demand Deposit Accounting	X	
Savings Accounting	X	
Trust Accounting	X	
Credit Card Accounting		X
Loan Accounting	X	

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will:	
	Not Use Common Carrier Lines	Use Common Carrier Lines
COMMERCIAL BANKS (Cont.):		
Transit	X	
General Ledger	X	
Computer Services for Customers	X	
Credit Authorizations*		X
Account Balance Inquiry*		X
Bank Management System*		X
On-Line Customer Services*		X
On-Line Transaction Entry*		X
Mathematical Simulation of Operations*	X	
Integrated Accounting*		X
Electronic Check Clearing*		X
Customer Computer Services		X
HOSPITALS & MEDICINE:		
Billing		X
Dietary Management*		X
Clinical Laboratory Scheduling & Reports*	X	
Radiology Treatment Calculations *	X	
Blood Bank Records		X
Shared Hospital Accounting System		X
Centralized Doctor Billing		X
Hospital Information Systems*		X

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will: Not Use Common Carrier Lines	Use Common Carrier Lines
HOSPITALS & MEDICINE (Cont.):		
Statistical & Mathematical Analysis		X
Medical Information Retrieval*		X
Instrument Signal Acquisition & Analysis	X	
Patient Monitoring*	X	
Multiphasic Screening (computer analysis of health examination data)*	X	
Computer-Aided Instruction*	X	
Clinical Records System*		X
Adverse Drug Reaction Reporting*		X
Administrative Control System*	X	
Computer-Aided Diagnosis*		X
Regional Medical Information System*		X
PUBLIC UTILITIES:		
Customer Information System:		
Billing		X
Accounts Receivable		X
Customer Inquiry		X
Credit & Collections		X
Service Order Entry		X
Materials Management System		X
General Accounting	X	
Stockholder Records	X	

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will: Not Use Common Carrier Lines	Use Common Carrier Lines
PUBLIC UTILITIES (Cont.):		
Construction Management System		X
Facility Planning		X
Electric Load Flow Calculation	X	
Short Circuit Study	X	
Transient Stability Calculations	X	
Loss Formula	X	
Rate Studies*	X	
Substation Monitoring & Control*		X
Plant Management System*		X
Distribution Management*		X
Economic Dispatch*		X
STATE & LOCAL GOVERNMENT:		
Appropriation & Fund Accounting		X
Payroll		X
Vendor Performance Files	X	
Purchase Order Writing	X	
Budget Preparation & Management*		X
Program Budgeting*		X
Highway Management & Design		X
Transportation Planning		X
Traffic Data Acquisition		X
Highway Management Simulation*		X

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will: Not Use Common Carrier Lines	Use Common Carrier Lines
STATE & LOCAL GOVERNMENT (Cont.):		
On-Line Highway Management Information*		X
Traffic Control*		X
Highway Engineering Computing Service*		X
Driver's License Processing		X
Vehicle Registration Processing		X
Driver Performance Records		X
Fee Accounting		X
Driver Training & Retesting*	X	
Vehicle Diagnosis & Inspection*		X
Accident Analysis*	X	
Parking Garage Control*		X
Statutory Retrieval	X	
Legislative Bill Status & Indexing	X	
Legislative Committee Scheduling*	X	
Legislators' Information Retrieval	X	
Judicial & Law Enforcement Information Systems		X
Citation Processing	X	
Police Resource Allocation*	X	
Police Command & Control Systems*	X	
Tax Billing & Allocation	X	

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will:	
	Not Use Common Carrier Lines	Use Common Carrier Lines
STATE & LOCAL GOVERNMENT (Cont.):		
Accounting, Budget Preparation	X	
Payroll & Personnel	X	
Local Government Planning*	X	
Pollution Control*		X
Court Scheduling*		X
AIRLINES:		
Crew Record Maintenance		X
Fuel & Oil Consumption Analysis	X	
Jet Flight Planning		X
Aircraft Performance Analysis	X	
Inventory Control		X
Labor & Material Reporting	X	
Reservations Systems		X
Passenger Sales Analysis	X	
CAB Statistical Reporting	X	
Revenue Accounting	X	
Service Controls	X	
Purchasing		X
Weight/Balance Optimization*		X
Aircraft Scheduling*	X	
Network Analysis*	X	
Maintenance Control--Air Frame*	X	

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will: Not Use Common Carrier Lines	Use Common Carrier Lines
AIRLINES (Cont.):		
Maintenance Control—Line Maintenance*		X
In-Flight Log Analysis*		X
Automated Cargo Control*		X
In-Flight Function Control*		X
Weather Prediction*		X
Flight Training Simulations*	X	
Navigation Monitoring*		X
In-Flight Maintenance Monitoring*		X
Failure Prediction*		X
Aircraft Ground Checkout*	X	
Corporate Information Systems*	X	
FEDERAL GOVERNMENT:		
Design Automation	X	
Simulation	X	
Linear Programming		X
Map Making	X	
Water & Air Pollution Analysis	X	
Loan Accounting	X	
Insurance Processing & Accounting	X	
Negotiable Instrument Processing	X	
Public Assistance Administration	X	
Hospital Administration	X	

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will:	
	Not Use Common Carrier Lines	Use Common Carrier Lines
FEDERAL GOVERNMENT (Cont.):		
Medical Research	X	
FDIC Accounting	X	
Regulatory Angencies--Statistical Analyses	X	
Personnel Records		X
Executive Profiles	X	
Student Accounting	X	
Budgeting		X
Appropriation Accounting		X
Payroll	X	
Military Operations Management		X
Military Games	X	
Guidance (missiles, aircraft, subsurface)	X	
Project Planning and Scheduling		X
Transportation Planning & Control		X
Property Management		X
Maintenance, Overhaul, Repair Scheduling		X
Supply & Inventory Control		X
Surplus Disposal Processing	X	
Material Storage & Transportation Processing		X

DATA PROCESSING APPLICATIONS IN THE NEXT DECADE

	The Majority of Systems Will:	
	Not Use Common Carrier Lines	Use Common Carrier Lines
FEDERAL GOVERNMENT (Cont.):		
Cataloging Inventories		X
Weather Forecasting		X
Construction Estimates		X

PART B: A SAMPLE EXTRACT FROM THE OVER 2000 APPLICATIONS OF COMPUTERS AND DATA PROCESSING

I. BUSINESS AND MANUFACTURING IN GENERAL

1. Office

Absenteeism reports
Accounts receivable: posting, rebilling
Advertising effectiveness: analysis, data handling
Air-Tube circuit
Attendance records: analysis, and evaluation
Billing and invoicing
Budgeting
Capital investment analysis
Catalog indexing
Charitable contribution
Consumer credit verification
Contract lists
Correspondence: personalized letters to delinquent accounts
Cost accounting, analysis
Data gathering from multiple locations
Depreciation calculations
Directory advertising calculations
Dispatching
Equipment registers
Expenses: analysis, prompt reports
File maintenance
Filing operations, single and multiple
Financial statements
Fixed assets accounting
Forecasting
General ledgers: operation
Hiring: analysis
Information retrieval
Insurance records and schedules
Inventory control
Inventory systems: simulation
Job placement: matching men with jobs
Labor cost determinations
Lease and rental accounting
Libraries: classification, records

APPLICATIONS OF COMPUTERS

Linear programming
Mailing list operations: addressing mail, bundling by address groups, "personalized" computer letters, updating and maintaining, zip code sequencing
Management: reports using the exception principle and others, games, simulation, statistics analysis, strategy analysis
Manhour records and analysis
Market research: studies
Message switching
Operations research applications
Optical character recognition
Orders: acknowledgement, analysis, processing, shipping
Overhead cost allocation
Overtime reports
Payroll: changes for general increases, computation and payment, overtime reports
Pension reporting and updating
Personnel: planning, placement, records
PERT charts: automatic drawing and up-dating
Performance evaluation
Plastic plates: emboss, codepunch
Price analysis
Production forecasting
Property accounting
Punched tape: Automatic production and reading
Purchase order writing
Questionnaire analysis
Record retention and destruction studies
Repair and maintenance: records, scheduling, control
Rent analysis
Retirement fund: records, valuation
Royalty processing
Salary advances
Sales analysis, area distribution, forecasting, quota calculations
Savings bond deductions
Seniority records
Social Security records
Systems: analysis, synthesis, evaluation
Taxes, calculation
Transportation optimization
Traveling salesmen scheduling
Turnover analysis
Vacation scheduling
Voucher distribution
Wage and salary analysis, records, tax computations
Warehousing and stocking: records, analysis
Work-in-process records

2. Plant and Production

Assembly line balancing
Cartons: automatic manufacture and packaging
Construction accounting
Construction job scheduling
Conveyor systems: designing
Critical path scheduling
Delivery scheduling
Dispatching control
Equipment capabilities: inventory, analysis
Factory operation simulation
Fuel consumption: records, analysis
Industrial accidents: analysis
Inspection: planning, scheduling
Inventory: control, record maintenance
Job standards: determination
Labor.management: remote terminal payroll system, scheduling
Labor utilization: analysis
Lathe operations: automatic control
Machine loading schedules
Machine tools: numerical control, control for automatic reproduction of complete parts
Machine utilization: analysis, job allocation
Maintenance: records, analysis, scheduling
Manpower utilization: analysis, schedules
Materials and parts: requirements, allocations, scheduling, control
Operational planning
Optimum ordering: determination
Parts catalogs: changes, construction, control
Parts design: evaluate modifications
Parts replacement service: scheduling, control
Power used: reports, analysis
Precision artwork
Precision measuring
Procurement
Product: grading, designing, marketing, testing
Production: forecasts, information analysis, scheduling
Production operations: determination of optimum order
Quality control
Repairs: records, analysis, scheduling, control
Route accounting (bakeries, bottling plants, dairies, etc.)
Routing cable and electrical wiring
Salvage records

Scrap reporting
Shipping control
Shop scheduling, optimum
Shrinkage calculations
Traffic control
Truck maintenance
Warehouse automation
Work standards: coding analysis

II. BUSINESS -- SPECIFIC FIELDS

1. Educational and Institutional

Administration:
- analysis
- attendance records: analysis processing summaries
- budgeting
- buses: routing, scheduling
- classes, scheduling
- courses, scheduling
- exams, scheduling
- honor rolls, compilation
- records, maintenance
- report cards: preparation, issuance
- revenue and expense accounting
- rooms, scheduling
- sections, scheduling
- student loan applications: processing
- student records: interpretation, processing
- student registration
- supply accounting
- teacher scheduling
- teacher credential issuance
- test results, compilation

Alumni records: analysis mailings, maintenance
Aptitude tests: scoring, analysis
Audio-visual instruction
College board examinations: interpreting, scheduling, scoring
College selection: aiding high school students to select colleges
Computer-assisted instruction --
college
- chemistry
- languages

mathematics
medical
physics
programming via Braille
statistics

elementary:
arithmetic
history
reading

high-school:
algebra
biology
languages
physics

medical:
patient simulator training programs for nurses, interns, medical students, ward attendants

Curriculum searches: instructional aids
Identifying "underachieving" bright students
Laboratory experiments: automatic control
Language teaching
Matching teachers with job vacancies
Personality test analysis for counseling
Teacher standards evaluation
Teaching
Test grading
Training Manuals: preparation, maintenance
Vocational decision making

2. Government

Accident records: accident repeater lists, safety programs, analysis
Adoption: matching prospective parents and hard-to-adopt children
Air mail extracting
Air-conditioning plant: control
Air traffic control, automated: radar data processing, radar tracking of aircraft
Appropriation accounting
Budgetary control
Census analysis
Commercial development planning
Computer auditing computers
Contracts: detection of collusive bidding
Corporate records: computerized
Detecting unlicensed television and radio set owners (Netherlands)

Draft: investigation, analysis
Driver license applications: checking, processing
Driver records: automated
Drivers' licenses via remote control: amending, duplication, issuing to qualified new residents
Drug control
Economy: simulation of sections
Election returns: analysis, processing
Emergency procedures testing: disaster simulation
Fire: research, simulation (a Building fire), statistics
Fire department false alarms: forecasting
Fires, forest: analysis, reduction
Fiscal accounting
Floods: automatic warning system, evacuation preparations
Foreign policy analysis
Garbage collection service: route scheduling
Hack licenses recording
Highway toll and service area revenues processing
Highways: maximum speed determination
Housing control
Income tax accounting
Income tax checking: nationwide
Inventory: office properties listing
Land use surveys
Legislative bills: drafting, editing, final copy preparation, information retrieval, printing, processing, redrafting, revising copy, status reports, updating
Legislators: research of proposed laws, state expenditures, monitoring
Mail: deliveries, scheduling, routing, sorting, volume determination
Motor vehicles: excise tax billing, registration
New drug application processing
Parts cataloging
Payroll: computation and payment, earnings statements, reporting, W-2 forms, automated
Political district reapportionment
Postage stamps: design (Netherlands)
Property right-of-way analysis
Property value analysis
Public Health --
- Air pollution: analysis, detection records, research, standards program development
- Aqueduct control
- Multiphasic Health Screening Exam Program: data summarization and print-out, electrocardiograms - analysis, transmission, print-out, information storage and

retrieval, statistical summaries
Poison control file: poisons and their antidotes
Radiation studies
Water pollution: analysis, control, monitoring, studies
Water purification studies
Radio station licenses: issuance
Roads, maintenance
Rubbish disposal planning, route analysis
Sales tax collections: funds, distribution calculations, retailer's records, updating
Sewers: customer listings, maintenance, rates revenue
Sidewalks, maintenance
Site-selection: computer-based
State warrants: writing
Statistical analysis
Street index and inventory system
Supplies: inventory and control
Taxes: refunds, processing, statement preparation
Town planning
Traffic: accident frequency pattern analysis, accident statistics, control, flow computation, signal regulation, simulation, summonses, ticket control
Traffic density: pictorial simulation
Traffic interchanges: designs of angles and grades
Traffic lights: maintenance control
Unemployment: information and claims processing, matching job openings with unemployed
Urban renewal planning
Vital statistics (births and deaths)
Waste disposal studies: simulation
Water pollution: graphic display
Water supply: customer listings, distribution supervision, meter reading, automatic, monitoring systems, pollution detection, rates revenue
Workload and manpower fluctuations

3. Hospitals

Administration: control
Autoanalyzers: monitoring
Billing
Blood banks: control, inventory, needs, usage
Clinical observations: analysis
Clinical research information: storage, analysis
Clinical tests: patient scheduling

Diagnosis and treatment: providing information on-line
Drugs: dipensing, inventory control, purchase order print-out, re-order, automatic, tracking
Electrocardiograms: analysis
Food: cost control, menu planning, nutrient value control
Health check-ups
Health insurance: hospital admission approval
Inventory
Outpatients: appointments -- processing, follow-ups, records, traffic scheduling
Patient billing
Patient data: on-line gathering and processing
Patient menus: planning
Patient records: analysis collation, medication file(drug history), summaries
Patient's condition during operation: recording and reporting
Physiological systems and conditons: quantitative study
Poison control center
Prescriptions: checking, label print-out, orders, prescription print-out, verification
Supplies: records, control
Surgery scheduling
X-rays: patient scheduling

4. Law

Documentary evidence for court cases: organization
Judicial decisions: simulation of
Laws: analysis, consistency studies
Lawyers: court assignment for indigents
Legal research
Legal services to disadvantaged: case summaries, writing, client records, maintenance, legal correspondence, preparation, legal documents, preparation
Magistrate courts: records
Patent searching
Pretesting of proposed legislation
Property right-of-way: analysis, determination
Property value: analysis
Reconstruction of decisions (using statistical methods) re: taxes, trust funds, public utility rates
Statute retrieval
Title searching
Writing title policies

5. Libraries

Archival material, automated control
Book purchasing
Card catalogs: maintenance and updating
Circulation control
Index: production
Information retrieval
Inventory
Magazines, Journals: ordering, controlling
Overdue notifications
Records and control
Registration; computerized

6. Police

Arrests: record
Ballistics: identification
Crime occurence: pattern analysis
Criminal identification
Fingerprints: identification, processing, searching
Local law enforcement: command and control system, driver's license and registration file, motor vehicle registration file, stolen motor vehicle file
Message switching
Missing persons file
Road blocks: setting up
Stolen automobile: identification
Stolen property: information storage and retrieval (national file)
Traffic law violations: accounting, analysis, recording
Wanted persons: information storage and retrieval (national file)

III. SCIENCE AND ENGINEERING

1. Economics

Household simulation
Industry: analysis, simulation of competition
Input-output analysis
Input-output models
Leontief models
Mathematical models of investment planning
Nonlinear economic models

2. Medicine and Physiology

Ambulatory clinic, records control
Anesthesia: control, simulation
Arterial physiology research
Alveolar gas parameter computation
Bacteria in photographs, slides: counting
Ballistocardiogram analysis
Biologic rhythm studies
Blindness: early detection and treatment
Blood: analysis, cells in photographs, slides (counting), chemistry determination, flow analysis, grouping and typing, hemodynamic studies, red cell volume (calculation, supply and distribution control, vessel distensibility, determinations), vessel wall properties, volume (calculation of total amount in circulation and loss)
Body functions (human): simulation
Bone crystal structures: calculations
Brain (human): cerebral slow waves (correlation and spectral analysis), functioning studies, life determination studies, pain-transmitting area, location research (basal ganglia functions, cerebellar functions), responses to light simulation, simulation
Cancer: cell growth simulation, diagnois, patient histories, registry compilation, treatment
Carbon monoxide studies: analysis, data collection
Cardiac patients, monitoring: arterial blood pressure, central venous pressure, heart pumping rate, output
Cardiovascular physiology studies
Cervical and vaginal smear screening
Cervical cancer incidence: analysis, data compilation, predisposition studies
Clinical data: statistical analysis
Compartmental rate exchange parameters
Coronary artery disease prediction
Cytophotometric analysis
Dermatoglyphic diagnosis
Diagnois: medical
Diagnostic possibilities: comments, listing, suggestions
Disease patterns: recognition of
Drugs: data retrieval, effectiveness analysis, prediction of body response to new drugs, study of diverse reactions
Drugs, effects of: animal studies, human body studies
Ear (human): cochlea, simulation; hearing defects of newborn child, determination of, hearing loss: testing analysis, simulation for hearing analysis, simulation for speech analysis

Eating habit pattern
Ecological system simulation
Electrocardiograms: analysis, integration, on-line monitoring, print-out, transmission
Electroencephalograms: analysis, diagnostic report
Enzyme kinetic representations
Epidemics, simulation of
Eye: disorders simulation, lesions - site, stability, and nature of: studies, muscle studies, physiology of, analysis, pupil servomechanism analysis, retinal responses to light, simulation
Fatigue research
Gastrointestinal tract: blood presence, detecting and monitoring, pressures, detection and recording
Gene frequency calculation
Growth and physique studies
Hand, artificial: controlled
Heart: catheterization monitoring, electrical discharges, analysis, fetal heart beat recording, heartbeat analysis, motion picture analysis (living heart), output - dye dilution curves, studies
Heart disease: screening community population for presence of
Heart pump: computerized
Hypertensive pressure computations
Intestinal absorption rate measurement
Intracranial lesions - site, stability and nature of: studies
Iodine metabolism computation
Isotope medicine: radioisotope scans: analysis, tracer studies: analysis
Lung disease detection
Malignant tissues, locations
Medical data: telemetering and analysis
Medical literature: indexing, analysis
Medical profiles: compilation
Medical tests: analysis
Medication administration schedules
Memory (human) research: short-term recall studies, stored information retrieval analysis
Mental disorders: diagnosis
Metabolic control involving chemical feedback
Motor system coordination testing
Muscle, skeletal: behavior studies
Neural events: studies
Neuroelectric data processing
Neuron signal conduction theory

Nerves, peripheral: behavior studies
Nutritional intake analysis
Optimum therapeutic procedure determination
Organ transplants: donor-recipient matching
Organic chemical compounds: effects of -- in malaria radiology, schistosomiasis, etc.
Pacemakers: status analysis
Patient history recording
Patient simulators for training in anesthesiology
Patients, critically ill: monitoring
Pediatric psychiatric diagnosis
Pharmacological research: patient simulation
Phonocardiogram analysis
Post mortem examination analysis
Probability in medical diagnosis
Prognosis: medical
Psychiatric test scoring
Pulse analysis
Radiation therapy
Radio frequency waves: effects on biological macromolecules -- studies
Renal function simulation
Shock therapy: monitoring of patient condition
Speech research
Strokes: Studies
Surgery, open-heart: blood infusion, postoperative monitoring
Symptom-disease complexes
Temperature of man: simulation
Thyroid disease: diagnosis
Toxicity data analysis
Tumors, location
Veterinary medicine: records processing
X-ray analysis

APPENDIX III

DATA BASE OF FORECASTS PERTAINING TO DEVELOPMENT OF COMPUTER TECHNOLOGY: PRESENT--YEAR 2000

The two parts of this appendix comprise a part of the data base which has been utilized in the Computer Pilot Study of the Technology Assessment Project.

Part A contains a substantial number of projections concerning the applications of computer technology. This information was obtained from the Parsons and Williams Study, Forecast 1968-2000 of Computer Developments and Applications. This was a European study using a modified Delphi Technique.

Part B, "Data Bank of Events," consists of an excerpt from A Fifteen-Year Forecast of Information-Processing Technology by George B. Bernstein.[70] Associated with each event are evaluations as to whether or not it would be a major event, its desirability, feasibility, and expected time of occurrence. Bernstein's report presents the results of a technology forecasting project which utilized a modified Delphi Technique called SEER. Round I of that project provided a data base; Round II refined, extended, and structured that data base to enhance its value for planning and for system design personnel. A group of over 45 outstanding individuals in the field of information processing participated in the activities of Round II. The group included representatives from the Federal Government, industry and the academic world. Each evaluation included in Part B of this appendix is the consensus of members of that group.

PART A: COMPUTER APPLICATION FORECAST*(71)

JURISPRUDENCE	The application of EDP in jurisprudence presents delicate political problems and could easily influence democracy as known today.
1970 Decade	Computerized storage and retrieval of data bank for legislative and criminal justice agencies.
Before Year 2000**	Certain standard types of jurisdiction (e.g., traffic violations) could be dealt with entirely through computers.
MONETARY SYSTEM	The service of EDP transfer and accounting of money is currently being introduced. Future progress will be decided by successful identification of individuals interacting with automated banking and finance systems.
Late 1990	Widespread use of EDP-transfer of money but not universal. Psychological factors contribute to reluctance in universal acceptance; the number of banks may decrease drastically as a result; people classified as credit risks may be totally isolated from access to financial service.
TAXES	The idea of instant collection of tax as income is received has been discussed extensively in the EDP field. Few attempts to apply this have been made thus far. EDP is normally used only in tax collection agencies to make retrieval and storage of account data easier.
1982–1990	Recording of all income by the majority of employers on terminals and automatic transfer of this information to tax authorities. Strong opposition to such a system was voiced in the EDP community.

* This forecast used a form of the Delphi Technique.

** Less likely than other events.

COMPUTER APPLICATION FORECAST

AUTOMOBILE TRAFFIC	Automated control of traffic flow to set speed limits, time traffic signals and route the heaviest concentration of traffic will help improved road safety. Traffic law enforcement will also be assisted by automated systems.
1973-1979	The direction of large urban traffic flows by computer is expected to be common practice.
1980-1986	Policing of individual vehicles by combined radar detection and computer recording of violation (license number, excessive speed, etc.) Semiautomated systems using a computer to store and retrieve violator information are beirg tested today; however, detection, monitoring and recording of violations are largely performed by people.
1990	Widespread use of auto-pilots on automobiles to electronically control acceleration, braking and distance between cars.
EDUCATION, LIBRARIES AND SCIENCE	Computer Aided Instruction (CAI) is expected to be a valuable new means of educating all ages in the future. Such systems might increase the efficiency of teaching and thereby reduce time needed for learning a new subject or skill.
1975-1981 (1978)	Widespread use of CAI systems; a network with many terminals installed in schools and universities connected to a few large scale computers.
1985-1998 (1992)	Drastic changes in book libraries with computers assuming the functions of storing abstracts, and retrieving documents. (Such systems will be expensive.)
1979-1986 (1983)	Maintaining updated status of scientific and other advances in central files. (Emphasis on control and protection of national and commercial interest,difficulty of classification; and technical problems of developing flexible central file systems will be limiting factors.)

COMPUTER APPLICATION FORECAST

MEDICINE	Medical electronic data processing is being used for administrative and clinical functions such as patient's record keeping, work flow planning in laboratories, medication scheduling and monitoring of patients under postoperative or intensive care. In the next two decades EDP will enjoy wide-scale use in all aspects of medical care, including diagnosis and pathology research.
<u>1974-1980</u>	The use of electronic monitors and computers will be integrated into day-to-day hospital operations.
<u>1980-1987</u>	A majority of doctors will have access to terminals for consultation with specialists, beginning in large hospitals and spreading to private practice; a strong network of computer and terminal aid for doctors is foreseen.
1976-1989 <u>(1983)</u>	Computer diagnostic programs are expected to give reliable results -- computers as a final decision maker is not foreseen. There will be broader application of computers in medical research, e.g., the grading by computers of diseases in order to recognize disease patterns and simulate the effect of illness in patients.
INDUSTRY	Several complete computer-controlled factories exist today. A gradual growth of automated factories is foreseen but not dramatic acceleration. Small industries will probably not be automated. Computerized information systems on the other hand may experience fast growth.
<u>Before 2000</u>	Complete automation of industry not feasible.
<u>1980's and 1990</u>'s	Steady but gradual growth rate in factory automation, starting in departments of very large factories then expanding to cover all large firms and medium-sized factories.

INDUSTRY (Cont'd)

No Date	Fast growth toward the implementation of integrated electronic information systems which will connect geographically distributed facilities and provide information exchange laterally and vertically across organizational units--manufacturing, sales, administration, research, etc.
1980-1990 (1984)	A 50 percent reduction of major industries' labor force due to automation. However, a strong demand for specialists is expected. Labor unions may slow the unemployment trend, counterbalancing the effects of automation.

COMMERCIAL AIRPLANE TRAFFIC

	More automation will be introduced to control all stages of commercial flight from take-off, en-route to landing. Computerized auto-pilots are still in the research phase.
1975-1985 (1979)	Complete computer-controlled commercial airplanes, including take-off and landings.

PRIVATE HOMES

	It is commonly believed that computers will one day be found in nearly every private home. It will likely be a terminal with access to one or more large data banks. The cost of such equipment and services will be comparable to high price tag appliances.
1990's	A strong trend toward the use of private computers and/or terminals. Computing equipment will be as common as telephones and television today in many countries; some units will be built into houses. Data communication cost may be a delaying factor. Newspapers as known today will be partially eliminated. Human reading habit of conventional printing may perhaps not be affected.

RECAPITULATION

A summary of the general trend in computer development as indicated in the Parsons and Williams study is presented in the following discussion. The future of EDP will be based in large measure on networks of small terminals connected to central computer systems. Some terminals will be small and medium size computers themselves. Two of the reasons for this trend are the following:

(a) Major EDP costs in the future will be storage devices making it economically necessary to share them.

(b) Small customers will want to use large computers to solve more sophisticated problems.

This future network will comprise few very large computers, several medium-size and many small general-purpose computers and terminals. Until the year 2000, general-purpose computers will continue to dominate the scene. Specialized computers will also exist, but will be used for control functions in production and in operation of machinery.

PART B: DATA BANK OF EVENTS

Part B of Appendix III, Data Bank of Events, consists of a 10-page sample from the approximately 50 pages of "Data Bank of Events" contained in the Bernstein study.[72] The sample consists of Category 13, namely Systems and Applications.

Each of the events in the Systems and Applications Category is evaluated in the four ways which are described in the following quotation from the referenced study:

" 1. Goal - The experts were asked to designate major events. Those events designated by the category panel as major were treated as potential goals. Those goals considered to have a better than 50% probability of being achieved by 1975 were designated as short-term, signified by S. Those goals not meeting the short-range requirement yet having a better than 50% probability of being achieved by 1983 were designated as mid-range, signified by M. Those goals considered by the experts to meet the probability of success requirement only after 1983 were considered long-range, signified by L. To prevent errors of omission, those events not qualifying as goals were designated not applicable, signified by N/A.

2. Desirability - The experts were asked to consider, from the user's point of view, the need to make the results of each event available as a usable product. The evaluation is expressed as an index from 1 to 9: 1 signifies undesirable but possible; 5 signifies desirable; and 9 signifies highly desirable. The value assigned to each event was calculated as an average rounded to the nearest whole number. The intermediate desirability index values then indicate moderating degrees of intensity.

3. Feasibility - The experts were asked to evaluate, from the producer's point of view, the technical, economic, and commercial feasibility of converting the event into a usable product. The evaluation is expressed as an index from 1 to 9: 1 signifies unlikely but possible; 5 signifies feasible; and 9 signifies highly feasible. The value assigned to each event was calculated as an average rounded to the nearest whole number. The intermediate feasibility index values then indicate moderating degrees of intensity.

4. Timing - The expected time of event occurrence is depicted by a triangle: the year by which there is a 'reasonable chance' that the event will have occurred (probability of 20%) is indicated by the left tip; the year by which the event is 'almost certain' to have occurred (probability of 90%) is indicated by the right tip; and the 'expected' year of occurrence (probability of 50%) is indicated by the vertex."

CATEGORY - 13. SYSTEMS AND APPLICATIONS

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
a.	Navy computer networks which can interchange information with other remotely located computers over communication links, such as the process of letting bids on a job (i.e., reducing it from months to hours).	N/A	6	7	70 ▽ 73 (71)
b.	Artificial intelligence - computers that learn, think, create, etc.	N/A	5	3	78 ▽ 90 (85)
c.	Man-connected computer systems in common use for control of eye movement, muscle or brain waves.	N/A	2	4	75 ▽ 90 (84)
d.	A large number of small computers on-line with a central system will become commonplace.	N/A	5	5	71 ▽ 79 (75)
e.	Small modular computers will be built into experiments as part of the control or data acquisition system.	N/A	5	8	68 ▽ 76 (72)
f.	In many system purchases, components will be obtained from different manufacturers, e.g., main frame from manufacturer A, memory from manufacturer B, peripherals from other manufacturers, etc.	N/A	5	8	69 ▽ 72 (70)
g.	The advent of watch-like computers will change the requirements for central time-shared machines and turn them into message switchers, large remote batch systems and libraries.	N/A	5	5	74 ▽ 81 (78)
h.	The advent of watch-like computers will radically change our views of present communication, information handling, displays and data capture. In fact, they may become the prime terminal.	N/A	5	5	74 ▽ 81 (78)
i.	High storage-density optical media for information storage and retrieval with variable magnification viewing and insertion of data into video displays will be available (i.e., microfilm = microphotographics).	N/A	6	8	68 ▽ 70 (69)

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
j. Centralized blue print files using film chips will become feasible. Chips will be retrieved automatically, scanned and relayed over wide band lines.	N/A	6	5	69 72 70
k. Widespread use of graphics systems for management and planning. Display consoles available to managers and their staff providing access to the accumulated information resources of the country.	M	8	5	71 80 75
l. Widespread use of computer aided design techniques for structures, ships, planes, autos and component parts.	S	8	8	69 75 71
m. Widespread production of motion picture and TV for both education and entertainment utilizing computers for both design and display.	N/A	5	7	71 80 75
n. On-line color TV will permit computer user to "tune-in" and follow the course of his problem in real-time.	N/A	5	5	75 85 80
o. Processing of data directly into CRT for making of movies depicting solution of problem.	N/A	6	5	70 78 73
p. It will be possible to produce machine tool tapes directly from a graphic input station.	N/A	5	8	70 80 75
q. Improved displays for data retrieval utilizing alphanumerics and/or graphics in an <u>application-oriented</u> format and process for ready assimilation and use by non-EDP trained functional personnel.	N/A	8	8	69 73 71
r. As equipment costs become lower and labor costs go up, it may be expected that much wider use of point-of-origin gathering of data will occur.	N/A	7	6	70 77 74

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
s.	Combined analog/digital systems will appear including tapė for storage and retrieval of photographic data with digital data.	N/A	5	6	73 / 76 / 80
t.	3rd generation hardware lifetime will be extended by memory extension.	S	6	7	70 / 71 / 72
u.	Systems providing access to "library" type data with hard copy output via simple electronic I/O device (direct transmission) will be operational on a local city basis.	M	6	6	73 / 78 / 81
v.	Low cost stored program processors will link the local retail outlet to powerful central processors for inventory control and accounting.	S	6	8	70 / 72 / 76
w.	Computers with many (thousands) remote terminals netted together across nation and world-wide doing cooperative problem solving.	M	6	6	73 / 75 / 80
x.	Library data will be available on home TV sets.	N/A	5	5	80 / 90 / 2000
y.	Low cost stored program computers with many teletypewriter terminals will serve as local message collection and distribution terminals and provide access to primary communication systems.	S	8	8	70 / 73 / 78
z.	Multilevel computer and terminal networks with some processing done at terminal, some at 1st level computer geographically close, some at 2nd level computer further away and more powerful, etc., will be developed. All processing will be done at the lowest possible level in the network to minimize communication costs.	N/A	8	8	71 / 73 / 75
aa.	Remote inquiry stations combined with television will provide over 50% of college education for engineering students.	N/A	4	4	74 / 78 / 83

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
bb.	Keying errors will tend to be overcome with verified prerecorded message composers being used at remote data input stations.	N/A	6	8	69 72 70
cc.	Low error rate, human operated, remote keyboards, used with self-checking numeric systems will be used in parts ordering, inventorying, etc. in conjunction with central computer systems and DDD communications.	S	8	8	68 70 69
dd.	Video-data combinations will be recorded on magnetic cards and color image transfer to follow up to be used for instance on routine service instructions (home office - district office, etc.), intelligence work, etc.	N/A	8	8	71 75 73
ee.	Information will be universally stored on a machine readable medium, rendering recopying by hand obsolete.	N/A	8	5	68 85 75
ff.	Touch Tone input to remote microfilm Retrieval Systems and graphic print out.	S	5	6	69 73 71
gg.	Improved software for microdigital recording of facsimile of printed or typed material, in the range of 100-1 reduction.	N/A	8	5	70 78 73
hh.	Drafting will be reduced to a set of codes which may be transmitted as easily as data. The engineer or the draftsman would compose a drawing in this new language and it would become as easily understood and recognizable as our present simplified drafting practices.	N/A	8	6	71 75 73
ii.	Information banks will be established on the basis of professions, types of equipment, technologies, special fields of interest, etc. They will do their searching on computer controlled basis; however, it is likely that microfilm will play a significant part in it, either as the information store or as the means of delivery of the information.	N/A	3	5	75 85 78

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
jj.	Instead of buying books and going to libraries for information, a student will be issued a reader and complete sets of microfilm with his entire course of study and all of the associated reading materials. The cost would be sufficiently low that the convenience to him would be worth the cost. The ability of microfilm to be distributed quickly and easily and updated would make it possible for additional materials to be handed out easily and quickly to be added to the collection in case the art is advancing or additional materials become available.	N/A	5	7	72 75 80
kk.	Use of microforms in the home will be accelerated by merchandizing in color microfiche catalogues read on home TV viewers.	N/A	5	5	72 74 78
ll.	Computer generated tapes for playback on inexpensive audio/video equipment will be prevalent.	N/A	5	5	76 81 87
mm.	Digitized voice/analog transmission between central offices and switching centers to facilitate time-division multiplexing, encryption and switching.	S	6	5	71 74 78
nn.	Full blown time-sharing systems which provide multiprogramming capability and remote terminal servicing will be available.	S	9	7	70 72 74
oo.	There will be substantial use of the on-line time-sharing computer systems which will facilitate the purchase of computing services at a reasonable price. Line costs will still be high, resulting in system costs which will prevent widespread use for some time.	S	8	6	69 70 71
pp.	Use of simulation to determine design of information storage and retrieval systems.	N/A	5	5	69 71 72

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
qq.	Modular, dynamically changeable command structures in on-line systems for rapid construction of easier man-machine interfaces which are particularized to individual users.	N/A	8	8	70 74 72
rr.	Man-machine capabilities to allow a user to examine in greater detail, at various levels, the output results of Management Information reports. With this would also come the opportunity to experiment more with overall results by causing changes in variables used in projecting from the bases established by using this stored information. The result would be a greater understanding by the user of the methods used to derive the information and what variables cause changes in what areas.	S	6	6	70 77 74
ss.	Management not making use of management information and control systems which are real-time current awareness call up systems will not be able to perform competitively.	N/A	5	6	70 75 72
tt.	Program restructurable systems.	S	6	5	70 74 72
uu.	User programmed systems without programmers. Programmer only used to program firmware.	N/A	4	6	73 77 75
vv.	Due to cost considerations, there will be an upsurge of remote batch processing systems which will have a depressing effect on interactive time-sharing systems.	N/A	2	1	69 72 71
ww.	Self-organizing software systems which given a generic description of a new capability generates new code.	M	6	3	72 77 75
xx.	Low-level machine assistance to indexing of documents	N/A	6	5	70 75 73

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
yy.	80% of work running on computers will be of a synergistic/symbiotic type.	M	5	5	74 85 78
zz.	Greater tolerance for error through the use of redundancy in the input and automatic error correction.	N/A	5	5	74 80 77
aaa.	User-oriented software and terminals.	N/A	8	8	70 72 71
bbb.	Powerful question-answering systems will be developed which can assimilate thousands of facts and algorithms and efficiently develop long deductive chains of these to prove a result.	N/A	8	5	70 76 72
ccc.	Systems will be designed to give both rapid retrieval from, and rapid updating of, large data bases to on-line users.	N/A	8	5	70 74 72
ddd.	Individual hand-printed expressions will be interpreted at the speed of writing and thus permit on-line hand-written input on a practical basis.	N/A	5	5	70 76 73
eee.	With the advent of time-sharing interpreters will assume greater importance in systems, and provide simpler processing of variability.	N/A	8	8	69 71 70
fff.	Simulation will be the standard tool by which operating systems are tested, designed and constructed.	N/A	5	7	69 71 70
ggg.	Software systems will contain complete data taking subsystems so that performance can be monitored.	S	8	8	69 71 70
hhh.	Software will be recognized as a product to be treated in production, testing and maintenance like other products.	N/A	8	8	69 71 70

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
iii. Development of machine-processable languages capable of representing and simulating the combined action of hardware and software systems at whatever level is desired, from logic elements through modules and more complex units.	M	5	7	72 – 77 – 82
jjj. A major increase in the use of computers for simulation is predicted facilitated by major changes in the use of peripheral equipment.	S	5	9	70 – 72 – 75
kkk. Cryptographic systems for normal business data will be in use.	M	5	9	73 – 75 – 80
lll. Automatic adaptive dissemination of information such as selective distribution of predetermined types of data.	S	8	5	70 – 72 – 75
mmm. An international technical data system will be in operation:				
(1) with access by company library via electronic I/O devices.	M	7	6	75 – 80 – 85
(2) with access by individual scientist through desk top devices.	L	9	3	80 – 86 – 91
(3) with electronic language translation capability provided.	L	5	4	90 – 96 – 2000
nnn. Central large computers will be available on phone lines in most large cities.	S	5	8	72 – 75 – 76
ooo. Laboratories, as we know them today, may go out of style as experimentation by computer will be less expensive than by other methods. Laboratories may be used only to validate the research done by computer.	N/A	1	1	85 – 2000 – 2100
ppp. Automation will have advanced farther, from doing menial chores to performing some rather sophisticated high-IQ functions.	L	8	2	74 – 85 – 95

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
qqq.	Complete interlocking of man and machine will be accomplished although the degree to which brain waves will be utilized is questionable; but man will be able to function as an integral part of an analog in systems sufficiently fast that the analog will make a half a dozen dry runs from which the optimum will be selected.	L	5	3	84 87 95
rrr.	Techniques will be perfected to isolate hardware and software malfunctions, postively.	M	8	5	70 75 80
sss.	Hardware and software purchases will be divorced.	S	4	3	68 72 75
ttt.	Marriage of computer-aided instruction techniques with standard information processing technology to effect error handling and reference manuals through user training.	M	8	8	72 75 80
uuu.	Operation of national or world-wide central data storage facility with wide access for general or specialized information retrieval.	M	6	4	75 80 85
vvv.	Office and home use of a computer utilize centralized on a city basis will become common.	N/A	4	5	75 80 85
www.	The majority of technical specialists will have access to a local typewriter terminal connected to a time-shared computer.	S	5	7	70 73 76
xxx.	Advanced communications terminals will allow many professionals to carry on their work at home, eliminating much person-to-person contact.	N/A	1	1	80 90 2000
yyy.	Need for Post Office services will decline, and be replaced by point-to-point digital transmission of information.	N/A	3	1	78 84 87

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Continued)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
zzz.	Breakthrough in long-range weather and sea state forecasting for Naval forces at sea.	M	8	6	72 — 80 (74)
aaaa.	Automated digital in-shore environmental data bank for major harbor and beaches of the world. It would include information about the currents, bottom geomorphology, surf, salinity, turbidity, for these in-shore areas.	M	6	7	72 — 78 (75)
bbbb.	Graphic arts quality printing using computer technology will be generally used throughout the industry.	M	5	8	75 — 80 (77)
cccc.	Development of more powerful capabilities in man-machine areas which lead, instruct and assist the user in obtaining desired results primarily via the use of CRT consoles in on-line, real-time situations.	S	7	7	70 — 77 (75)
dddd.	Personal terminals which "simulate" routine activities of employees in functional departments (e.g., personnel, contract administration, pricing, etc.) so as to increase productivity of administrative work.	M	6	4	74 — 80 (76)
eeee.	90% of the documentation required to manufacture an electronically based product will be computer generated in an acceptable format. Complete electrical documentation from logic designer at a terminal.	M	7	7	70 — 80 (75)
ffff.	Micro-electronic and medical technologies will reach the point where it will be possible to directly stimulate (by implantation or other means) the appropriate areas of the human brain in order to produce sights and sounds as an aid to the blind or deaf.	L	5	3	85 — 2000 (90)

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Concluded)

	EVENT	GOAL	DESIRABILITY	FEASIBILITY	TIMING
gggg.	The need for higher speed systems will continue to grow. Such systems will be designed and built.	N/A	5	5	69, 72, 75
hhhh.	The use of computers in the educational process will expand rapidly and significantly.	S	8	8	69, 72, 75
iiii.	Powerful capability will exist for modeling computer programs and computer systems such that predictions of "goodness" of computer hardware and software systems can be made reliably.	N/A	8	5	69, 72, 80
jjjj.	Computers will receive signals from radar sets, physical experiments, sensors, etc., and begin to organize them into meaningful structures.	N/A	8	5	73, 75, 77
kkkk.	A major increase in the use of small central processors suitable for procurement by individuals to perform such functions as climate and lighting control in the home, systematic information retrieval from various sources such as stock brokers, banks and retailers and scheduling of such functions as maintenance, budgeting and medical care.	M	7	6	72, 78, 84
llll.	Operating systems which integrate executive, generalized data management, and programming languages will become operational.	N/A	8	6	69, 70, 72

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