A Perspective on Information Resources

The Scope of the Program 1973-74

Program on Information Technologies and Public Policy

Harvard University Cambridge, Massachusetts

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As chairman of the Computer Science and Engineering Board of the National Academy of Sciences (1967-73), he led the preparation of NAS reports on *A Technical Analysis of the Common Carrier/User Interconnections Area* (Lewis S. Billig, Project Director), *Databanks in a Free Society: Computers, Record Keeping and Privacy* (Alan F. Westin, Project Director), and on *Libraries and Information Technology — A National System Challenge* (Ronald L. Wigington, Project Director). He is the author of *Automatic Language Translation: Lexical and Technical Aspects*, of *Run, Computer, Run: The Mythology of Educational Innovation*, and of numerous papers on the information technologies and their uses.

Associate Director

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A PERSPECTIVE ON INFORMATION RESOURCES

The Scope of the Program 1973-1974

Act as men of thought.
Think as men of action.
—Henri Bergson

Program on Information Technologies and Public Policy
October 1974

Harvard University
Cambridge, Massachusetts

CORE PROGRAM SUPPORT

American Telephone and Telegraph Company
Arthur D. Little Foundation
Encyclopaedia Britannica
Federal Reserve Bank of Boston
General Electric Company
Harvard University
International Business Machines Corporation
John and Mary R. Markle Foundation
Lockheed Missiles and Space Company
Nippon Electric Company
Southern Railway System
Zenith Radio Corporation

Available on request is a companion booklet, *The Program Year in Review*, describing the specifics of Program research, teaching and communication activities and its administration and finance.

CONTENTS page

1. Introduction 2
2. The Information Industries 4
3. A Coherent View of Information Systems 4
4. The Information Technologies 6
5. Program Strategies 10

	$ billions	
Broadcast television	**2.8**	FCC-regulated
Cable television	**0.3**	FCC-regulated
Broadcast radio	**1.1**	FCC-regulated
Telephone	**18.2**	FCC-regulated
Telegraph	**0.4**	FCC-regulated
Specialized common carriers	**0.0**	FCC-regulated
Satellite carriers	**0.1**	FCC-regulated
Mobile radio systems	**1.9**	FCC-regulated
Motion pictures	**3.8**	
Organized sports, theatres, etc.	**4.4**	
Computer software suppliers / **Computer service suppliers**	**1.9**	
Postal service	**6.3**	
Private information delivery services	**0.7+**	
Newspapers; wire services	**7.0**	
Periodicals (including newsletters)	**3.2**	
Business consulting services	**0.9**	
Advertising	**7.9**	
Marketing	**73.9**	
Brokerage industries	**40.6**	
Book publishing and printing	**3.4**	
Libraries	**2.1**	
Schooling	**70.0**	
Research and development	**26.6**	
Federal information institutions		
Census Bureau	**0.1**	
National intelligence community	**4.0+**	
National Technical Information Service	**0.0**	
Social Security Administration	**1.0**	
County agents	**0.3**	
etc.		
Banking and credit	**61.1**	
Insurance	**92.6**	
Legal services	**8.5**	
GNP (1970):	**976**	

Figure 1. The Information Industries Approximate Gross Revenues (1970)

INTRODUCTION

1

Information is a commodity that pervades all organized activity; its economic and social characteristics are unique and ill-understood. There are dozens of industries and governmental operations in which information is the primary or sole output, and yet there is no comprehensive source of even the most basic facts about the information industries as a group. The data on the various information industries are scattered and disparate.

The major reasons for this lack of information on information are clear. First, as shown in Figure 1, the information "industries" are a diverse group, including the Census Bureau and the Social Security Administration; Hollywood, Madison Avenue, Wall Street, and the Pentagon; Book publishing and printing, computer software, telegraph, telephone and satellite carriers. This just begins the list, but these are organizations employing millions of people and dealing in billions of dollars, employing varying technologies to achieve diverse missions, each developing independently with little reference to any but direct competition.

The second major reason for the lack of cohesive, comprehensive information on the information industries is the vast increase in the sheer amount of information processing that has occurred in the last 30 years. As Figure 8 in Section 4 shows, while population grew at an average rate of 1.5 percent a year between 1940 and 1970, the number of checks written went up 6.7 percent a year; the number of motor vehicle registrations went up at the rate of 4 percent; the number of individual federal tax returns grew at 5.8 percent a year; passports issued, at 16 percent; individual social security payments, at 17.1 percent. Improvements in electronics have greatly increased our capacity to handle information and greatly reduced the costs of handling information, but the rapid growth of the information industries reflects changes in society far beyond simple technological innovation.

A final reason for confusion and lacks in the data on the information industries is that these industries occupy an unusual public-private milieu with regulation on varying scales and of varying intensities, with competitive stances ranging from monopoly to fear of no-man's-land and with institutional energies ranging from torpid contemplation of the past to enthusiastic ambition for the future. Virtually all attempts to study the information industries have concentrated on particular cases and not on basic functions, on diversity rather than affinity.

In other words, the reason for the unclear view we have of information industries as a group is that very few attempts have been made to see them as a group. This notion of the importance of thinking about basic functions and not only about particular cases is not yet widely accepted in the realm of information services, but it has been usefully applied elsewhere. As competition grew from aluminum, plywood, plastics, glass fiber, and other materials, steelmakers came slowly to understand that they were supplying only one of many structural materials, and that many of steel's functions could be fulfilled by alternate materials. Similarly, most railroad men have learned, sometimes forcibly, that trains are but one of several competing modes of transportation. Oil, coal, electricity, radioactivity, the wind and the sun are alternate, competing sources of energy.

Alterations in the relations between oil and coal in the energy industries, or among trains, boats and pipelines in the transportation industries clearly have large implications for public policy. It is equally clear that changes in the relations between information industries have a similar impact on the public. It is also clear, however, that information is a very different kind of commodity, one that does not warm us or shield us from the elements but rather one that fills our heads and the memories of computers.

Thus, it is the thesis of the Harvard Program on Information Technologies and Public Policy that the public has a vital interest in the rapid and fundamental changes occurring in:

- how information systems perform
- who controls information flow
- and on what terms what information is made available to users to meet their needs for the knowledge and understanding required to participate fully in our society.

Of central importance is the question of who holds how much power over whom.

Today, major social, economic and technological factors are altering or eliminating the historic barriers between information industries and making new alternatives available to information users. Most notable are the vast increases since World War II both in transactions entailing information processing and in the capability and reliability of electronics, increases that go hand in hand with large decreases in the costs of electronic technologies. What therefore happens to one information industry strongly affects not only all the others, but also the public generally. These relationships have not been widely recognized and little is known about their effects on either the industries or the public.

It is the aim of the Program, therefore, to develop an understanding of information systems and information technologies and to use that understanding to illuminate public discussions of information policy and the information industries.

In this booklet, the sections that follow define the scope of the Program in terms of:

- services that private firms or government agencies now perform (Section 2, "The Information Industries")
- interactions among these activities (Section 3, "A Coherent View of Information Systems")
- social and technological changes taking place in the information industries and their markets (Section 4, "The Information Technologies"); and the basic questions arising from these changes and interactions.

Finally, broad "Program Strategies" are outlined in Section 5. These strategies are the principles which are used to get a grasp on an unwieldy and intractable field of study.

A frank and detailed account of the Program's work will be found in a companion booklet, *The Program Year in Review 1973-1974*. In substance, it describes the specific moves toward the broad objectives described in this booklet, and gives details of Program management and finance.

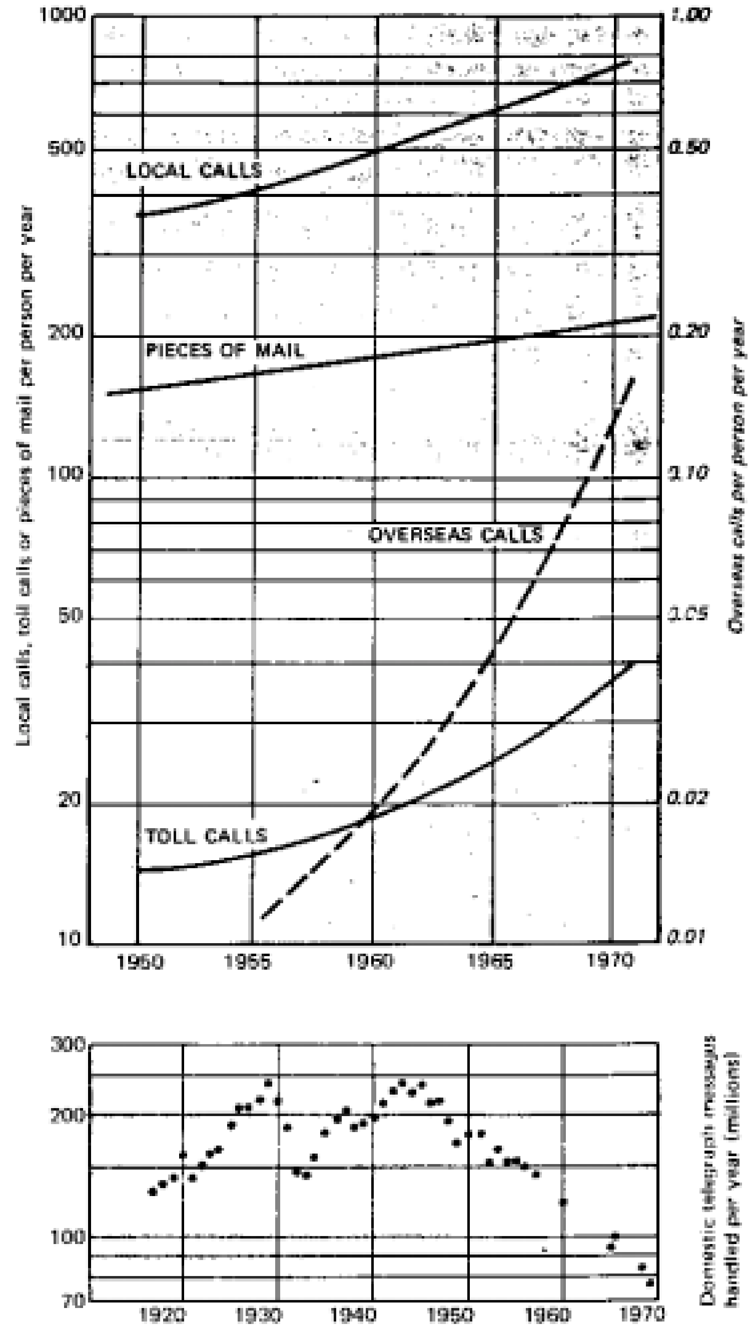

Figure 2. Mail and telephone use increases; telegraphy declines.
Information functions shift from one information industry to another. These charts, adapted from "Communication" by John R. Pierce (*Scientific American*, September 1972, p. 37), indicate a decline in telegraphy in recent years and a rapid growth in mail and telephone communication. Note that the charts are not comparable, and that two scales are superimposed in the chart on mail and phone usage.

THE INFORMATION INDUSTRIES

2

It is clear that an important task of the Program is to characterize the vast and varied information industries in terms germane to the aims of the Program. Some of the elements -- public and private -- of the present constellation of information industries are illustrated in Figure 1. A common trait of the listed activities is that, in each case, information is the *primary* or sole output. Excluded from the table, but important as information users, are all the industries where information processing, however important, is incidental to producing such primary outputs as cars or haircuts.

The Social Security Administration, the county agent system and the banking, insurance, securities and legal service industries are listed to mark the borderline suggested by such a "primary business test". Whether the output of these industries is information or something else is arguable. However, each industry's "production line" is essentially nothing other than an information processing line.

The scope defined by Figure 1 is ambitious, especially given the tradition that treats these industries as isolated or, at most, as clustered by the jurisdiction of the Federal Communications Commission. Of greatest interest are activities that interact particularly closely and are in a state of ferment. These have been placed at the head of the list and received the Program's initial attention. As the Program continues, criteria may emerge that will change the list and the order within it.

A COHERENT VIEW OF INFORMATION SYSTEMS

3

Historically, patterns of information use, of market structure, of public intervention, of analysis and of evaluation have developed independently in the information industries. Presumably, these patterns were adapted to the particular users, markets and technologies of each.

However, the record of the past decade suggests that the information industries are becoming increasingly intertwined. The technologies of computer systems and telephone systems for example, appear to be merging to the point that each may be soon considered as a branch of an overarching digital technology for information processing. This point is discussed in detail in Section 4.

This growing interchangeability and indistinguishability is a natural development because all information systems perform one or more of the following basic functions:

- *creating* information
- *storing* information
- *processing* information
- *distributing* information
- *using* information.

These information functions, of course, pervade all organized activity. In the information industries, however, they are *primary* functions. Elsewhere, they are *incidental* to some other primary role. Even the massive information processing performed by railroads or supermarkets qualifies them as important information users, but not as information industries.

As the primary functions of the information industries overlap, so do the technologies available to perform these functions. There are many more alternate technological means for creating, storing, processing, distributing and using information than there were at the close of World War II, or even just five years ago. (See Section 4) Figure 2 illustrates in simple form some of the shifts in choices of information-handling modes that have taken place since 1950.

The need for a coherent view of information systems, for a look at the processes that mold the structure and performance of information industries as a group, can be best indicated by some of the questions being asked about relationships within the group.

Many varied combinations of hitherto separate information industries are jockeying for control of old and new turf. The questions will be found in Figure 3 labeled "Business Questions".

Present differences in structure, in jurisdiction, in legal and other traditions among the information industries are as important to understanding how their interacting affects the public as are the growing similarities of basic functions.

Some of the information industries, for example newspapers and the telephone companies, are primarily in the private sector. Others are essentially in the public sector, like the Postal Service and the Federal information institutions. Still others are mixed, like libraries and schooling. Some, including the telephone and telegraph companies and the Postal Service, transfer information without exercising substantial control over what content flows among users. Others, including television, newspapers, book publishers and public schools create, process and disseminate information content.

Different traditions of government and other public intervention apply. The competitive book publishing and newspaper industries have been affected indirectly through devices such as taxation or postal rates (which side-step judgments as between "worthy" and "unworthy" publications that might interfere with the protection extended to content by the First Amendment) and directly as through censorship. The telephone and telegraph companies are monopolies subjected to economic regulation, but essentially free from intervention as to content, over which, in any case, they have little control. Intervention in television content is manifest through such devices as the Fairness Doctrine through governmental pressure, and through the actions of consumer groups before regulatory agencies or the courts. The public schools are instruments of state and municipal governments.

Although attention to government regulation has tended to focus on such means as the Communications Act of 1934, which created the FCC and on the copyright laws, the tools of government that may or may not be exercised range far wider, including:

- Taxes
- Tax write-offs
- Regulation of price, quality and entry
- Standards
- Research and development
- Prohibitions; financial and criminal sanctions
- Subsidies
- Rewards for innovation and invention
- Incentives, e.g., matching funds
- Model legislation
- Import/export trade management
- Information exchange

What determines... ?

Who shall deliver motion picture entertainment to the public? Movie houses, hotels, telephone companies, over-the-air broadcasters or cablecasters? Whether transportation or telecommunications shall be used to disseminate the pictures? Whether the service shall be paid for by advertisers, by the viewers directly, through private or public subsidies or by other means?

Whether data shall be carried from computer to computer or to and from terminals in businesses or homes by telephone companies, specialized common carriers, cable television systems, the Postal Service, or private information delivery services? Who shall own the terminals and maintain them to the users' satisfaction?

How services to learners will be allocated among the schools as we now know them, libraries, broadcast or cable television, publishers or new institutions, public or private?

Who among the banking, securities, telephone, telegraph industries, the Postal Service and private information delivery services shall perform which information services? (For example, some 40% of the mail deals with financial transactions, so that the fates of the Postal Service and of payment mechanisms are intimately linked.) With how much supervision by whom? The Federal Communications Commission, the Securities and Exchange Commission, the Federal Reserve System, associated Congressional committees or state authorities? Who shall set standards for media and formats of data transfer and storage?

Figure 3. Business questions.

Transactions (Mail containing checks, bills, statements of account, purchase orders, etc.)		40%
Advertising		26%
Correspondence		22%
Personal	13%	
Business	5%	
Government	4%	
Magazines and Newspapers		11%
Merchandise		1%

Figure 4. What's in the mail?

What's in the mail? Using figures from *Toward Postal Excellence*, the 1968 report of the President's Commission on Postal Organization, we can deduce the existence of a large overlap between information handling in transactions and the mails. Some 60 per cent of all mail is sealed letters. Thus, we see from this table that if sealed letters are primarily transactions and correspondence, two-thirds of the letter service may be devoted to transactions.

What determines...?

Whether broadcast traditions, publishing traditions or telephone traditions respecting control over information content shall prevail in cable television?

Whether the school board would pass on educational materials to be shown on a TV channel in the way it now passes on textbooks used in the school? Whether the Federal Communications Commission's Fairness Doctrine would apply? What a teacher's rights to switch to a noncurriculum channel might be? A student's? A parent's?

If the use of private facilities for state-approved learning continues to grow, what shall govern the rights and the obligations of teachers when, traditionally, private employers have had much greater freedom in hiring and firing employees than school boards have?

What happens to rights of privacy or to rights of access to information when the information itself is transferred from an institution following one set of traditions on this score to one following another? When the allocation of an information function flows from one industry to another? When information held by an international organization moves across national boundaries?

If satellite surveys of natural resources move from experiment to routine operation who shall operate such systems? Who shall have access to the information about natural resources and other data collected by these satellites? Whether operation and access shall be public? Private? National? International?

Figure 5. Social and legal questions.

- Establishing or supporting an industrial base by government purchase
- Institutional Invention
- Government control or monopoly
- Building civil works
- Propaganda
- Fear

This listing was adapted from Joseph F. Coates, *Structural Failure: The Case of Local Government*, a paper forthcoming in *Public Science*.

Because of the differing patterns of structure, jurisdiction and tradition among information industries, a shift in the performance of some basic information function from one information industry to another entails important social and legal questions and not only classical economic questions about returns to scale, price-setting mechanisms and so on.

Still broader questions arise when taking a more speculative longer point of view. Information, materials and energy are the fundamental resources essential to the physical and spiritual well-being of every living creature. Profound technological changes characterize all three realms. The already enormous and still forthcoming increases in the capacity and decreases in the cost of electronic information-processing devices can efface contemporary time and distance on a global scale and profoundly alter information flow over historical time. The very context of all other questions may thereby be altered, as illustrated by some of the long-range questions being asked.

In the opening discussion, we took note of structural materials, transportation and energy as precedents for the wider choice among alternate modes now available in information systems. But, in the United States, structural materials are primarily in the private sector, while information systems are spread in a complex pattern across the private and the public sector. The precedents of public intervention in transportation are not encouraging. Energy is in crisis. In any case, a fresh objective look at some basic questions is necessary and timely.

THE INFORMATION TECHNOLOGIES 4

The story of the growth since World War II of alternate technological and institutional means for creating, storing, processing, distributing and using information is mainly, though by no means exclusively, the story of electronics.

Figure 8 speaks volumes about how public and private transactions affecting millions of people and entailing massive information processing have increased in the past three decades, whether driven by, or driving, simultaneous advances in information technologies.

Advances in electronics continue swiftly in both the private and the public sectors. For example, in the public sector, defense research and development is still an important factor in electronics today, as it was in the development of electronic computers. According to testimony by the Pentagon's Director of Defense Research and Engineering, "military-oriented electronics technology continues

What determines ... ?

How patterns of access to information will be distributed among nations? Among individual citizens? What the likely effects of different patterns will be on political and economic processes? Locally? Nationally? Globally?

How joint growth or tradeoff among information and transportation functions will affect the distribution of people and of material and energy resources?

How the very suppliers and users of information themselves will be altered by changes in the means of learning? By the changes in organizational structure and changes in the pattern of power in organizations associated with new patterns of flow and control of information?

Figure 6. Long-range questions.

What are the implications for information users of jockeying among old and new information organizations for old and new information markets?

What are the likely effects on information users of increasing or decreasing competition among old and new information organizations?

How does the traditional mixture of private enterprises and public agencies serve information users? What would be the likely effects on users of shifting the allocation of any information functions from one industry or agency to another? From the public sector to the private sector or vice versa? From national to international control or vice versa?

How responsive are traditional patterns of governmental and other public intervention in information systems to the needs or demands of information users? What would be the likely effects of extending or curtailing intervention nationally? Internationally? What alternative patterns are available? With what likely effects?

What governs the nature and the rate of technological innovation in information systems; and with what likely effect on information users?

Figure 7. The Program's basic questions.

TYPE OF TRANSACTION	AVERAGE ANNUAL GROWTH 1940-1970
Checks written	6.7%
Telephones in use	6.2
Individual Social Security payments	17.1
Individual federal tax returns	5.8
Public welfare recipients	3.5
Airline passengers	14.3
Persons entering hospitals for treatment	3.8
Persons covered by private hospitalization insurance	9.5
Motor vehicle registrations	4
Passports issued	16
Students enrolled in colleges and universities	5.2
Applications received for federal employment	3.7
New York Stock Exchange transactions	8.3
Pieces of mail handled, U.S. Postal Service	3.6
U.S. population	1.5
U.S. gross national product	3.9

Figure 8. Average annual growth of various transactions.

Increases in the volume of annual transactions. Adapted from Alan F. Westin and Michael A. Baker, *Databanks in a Free Society* (a report of the Computer Science and Engineering Board, National Academy of Sciences), Quadrangle Books, New York, 1972, pp. 224-227. The GNP growth rate is based on GNP expressed in constant dollars.

Once upon a time, telephone technology seemed to be what the telephone industry used to supply telephone service. But the scientific and technological foundations of telephone systems and of computer systems are now merging as both increasingly rely on the same large-scale integrated digital technology for their information transmission, storage, processing and control functions. The boundary between the telephone system and computing has been the subject of a major inquiry by the FCC, but the issue is still wide open.

Motion pictures once meant only film technology, but motion pictures are now routinely recorded, stored and played back on either film or videotape, often under the control of computers. Digital recording of pictures exists, but is not yet routine. Once upon a time motion pictures had to be physically "bicycled" to theatres. Now they may also be electrically broadcast over the air or sent over telephone company or cable television lines to theatres, hotels or homes.

Cable television relies on coaxial cables to retransmit broadcast television material, including motion pictures, but also relies on microwave wireless technology to capture this material. Coaxial cables are also a major element of the telephone network where they are used, among many other functions, to transmit television pictures and computer data. Most computers also incorporate some coaxial cable. And, coaxial cable is by no means the only technology suitable for non-broadcast distribution of either television signals or computer data.

Printing, once associated exclusively with moveable, reusable slugs of metal type, increasingly relies on computer-aided composition directly onto film. Some visions of future home delivery of "newspapers" foresee an all-electric operation from the moment a news item leaves a reporter's hand at a keyboard, is transmitted over someone's wire or wireless service for display to an editor working at a TV-like screen, is assembled with other materials in a computer's storage medium and then is retransmitted over someone's wire, microwave link, light pipe, laser beam or whatever to the home television set of a reader who then has the option of capturing the text permanently through some form of dry-copying or printing technology.

The experimental Mailgram service links electrical transmission by the private sector with on-foot transmission by the public sector into a single system. Customers of the telegraph company with teleprinters on their premises transmit messages to post offices equipped with teleprinters where postal employees remove messages, place them in envelopes and put them in the first class mail stream.

Figure 9. Notes on merging technologies.

to be one of our fastest moving and most productive areas of applied research and development," accounting for $216 million or nearly 15 percent of the $1,474 million budgeted for the "total technology-base effort" in fiscal year 1974.[1]

The technological bases of computers and telecommunications are increasingly similar and both of these tools are increasingly pervasive as means for controlling and linking hitherto separate old and new technologies. The notes on merging technologies illustrate how this is a major factor in making the functions that information industries perform and the technologies they use both less distinguishable and more interchangeable.

The increasing pervasiveness of electronics owes much to massive increases in capability accompanied by equally massive decreases in costs, both in absolute terms and in comparison with older information technologies. For example, computing speed increased by a factor of one hundred million-to-one between the 40's and the 70's. By the end of the decade, a transistor could "be about as cheap as a word printed on the page of a hard-cover book."[2]

The cost per component (mostly transistors) of the first rudimentary integrated circuits made around 1960 was about one dollar. By 1973, this cost had dropped to about one cent and it is predicted to drop to about .003 cent by 1980, a ratio of thirty thousand-to-one in two decades.[2] In the same time span, the number of components per integrated circuit is expected to grow by a factor between one hundred thousand and one million-to-one. Similar factors in other dimensions are illustrated in Figures 10 and 11. In electronics, large increases in capability and large decreases in cost go hand-in-hand, along with significant increases in reliability.

At present, many of the information industries do not produce or control the production of their technology. A notable exception is the telephone industry. American Telephone and Telegraph owns Bell Laboratories and Western Electric for research, development and manufacturing. General Telephone and Electronics owns GTE Laboratories, Automatic Electric, Lenkurt and Sylvania.

The details and trends of common control patterns vary among major information technology suppliers such as Eastman Kodak, Hughes, IBM, RCA, Xerox, etc. But, with some exceptions (see Figure 12), these suppliers now are generally still distinguishable (both by function and institutionally) from the industries whose output is information itself. The structure and performance of these supplying industries is a matter of clear importance to the Program since the relationship between technology suppliers and information systems is a major factor in understanding how patterns of competition, function allocation and public intervention in the information industries affect the public.

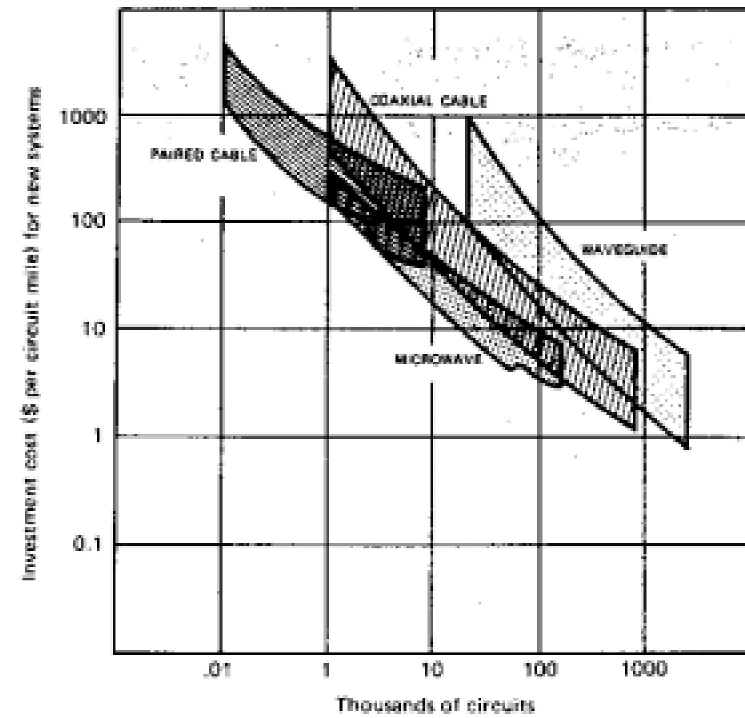

Figure 10. Costs of alternate methods of information transmission.

Cost trends for terrestial transmission of information are down while carrying capacity is up. Paired cable is the original telephone technology still in use; the others are later developments. The increases in the handling capacity of the four transmission systems represent developments over time as well as technical improvements. The investment costs are expressed as a range. This chart is adapted from staff papers prepared for the President's Task Force on Communications Policy, 1969.

[1] John S. Foster, in "Hearings on Cost Escalation in Defense Procurement Contracts and Military Posture and HR 6722", Committee on Armed Services, House of Representatives, 93rd Congress, First Session, 1973, p. 701. Another estimate has it that "the Pentagon's direct and indirect outlays for electronics and materials R&D will top $3.2 billion in fiscal 1974... The total, approximately 40% of the Department of Defense's $8.1 billion in planned R&D expenditures for the year, is not only the largest R&D outlay by far of any Federal Agency, its electronics content exceeds that of all other agencies combined... In fact, Federal support of electronics technology is as pervasive as electronics itself." *Electronics*, Oct. 25, 1973, p. 200.

[2] William C. Hittenger, "Metal-Oxide Semiconductor Technology", *Scientific American*, August, 1973, p. 48ff.

ACCESS TIMES

Typical today:	
Millions of bits	10-100 milliseconds (10^{-3} sec.)
Expected in future:	
to 1 billion (10^9) bits	1-100 microseconds (10^{-6} sec.)
to at least 1000 billion bits	100 milliseconds (10^{-3} sec.)
to perhaps 100,000 billion bits	1-10 seconds

TYPICAL ON-LINE CAPACITIES

Routine	8 Tape units	1-5 billion (10^9) bits
Routine	8 Disk units	1-5 billion bits
Borderline	IBM Photo-digital store	500 billion bits
Borderline	Precision Instrument Co. Unicon 690	1000 billion bits
Foreseeable	"New" disks	4-20 billion bits
Foreseeable	Optical technology	100-10,000 billion bits
Foreseeable	Electron beam technology	100-1,000,000 billion bits

SOME ROUGH COSTS

Paper	0.1-10 million (10^6) bits/dollar
Microfilm	1-100 million bits/dollar
Present disks	10,000 bits/dollar
Future high capacity stores	1-100 million bits/dollar

Figure 11. Information access time, storage capacity and costs.
The capacity for handling information will grow enormously in the next 30 years, judging from the technological innovations already in the works. Computers process information in "bits", each representing a "yes-or-no" answer, or the information represented by a single hole in a punched card. It may take several bits to express a word or number. Access to this information—taking it from the computer's storage capacity and bringing it to the area of the machine where it can be manipulated—is measured in the number of bits that can be retrieved in a given time. "On-line" capacity measures the amount of information that can be kept on the machine, comparable to the capacity of an automatic phonograph or a juke box. To get at more information you have to change storage units manually. The new technologies referred to utilize magnetic bubbles, lasers, holography or electron beams, which permit the packing of larger amounts of information into smaller spaces. As for the cost measure, a primary disadvantage of the microfilm or punched paper technologies is that the medium of storage cannot be renewed. Estimates are by John W. Weil, *Mass Storage and Databases—Technical Implications for the Future*, presented at Institut de la Vie Conference, Bordeaux, 1970.

PROGRAM STRATEGIES

5

As this booklet indicates, the Program on Information Technologies and Public Policy has chosen an uncommonly broad field of study. The aim is to develop an understanding of the information industries and to use that understanding to illuminate public discussions of information policy. Since the information industries have hardly been studied as a group, and since there are hardly any discussions of information policy as such in the public realm at present, our strategic considerations have been essential.

How are we to proceed in making a field of study out of this profusion of institutions and technologies, mailmen and soldiers, programmers and movie producers? How we did in fact proceed is the subject of a companion booklet, *The Program Year in Review*, but we will note here the principles that guide us.

First, we have met diversity with diversity. We have sought to develop the closest cooperation among specialists and generalists of the most varied kinds from inside and outside the university, from government and industry. By bringing these people together we hope to develop a common language for discussion of information problems. A common language, we hope, will overcome further fragmentation of knowledge, and foster a reasoned interplay of conflicting philosophies, opinions and points of view, not to mention prejudices and articles of faith.

We are aware that "interdisciplinary" is the first word that an infant research program learns, but we simply could not proceed if we were not able to support each other's endeavors. No other sort of research is feasible in this field.

Any research work has a tendency to sprawl and interdisciplinary work in a new broad field of study is hardly an exception. Our second strategic principle then has been to attempt to keep each research project within manageable proportions and to allocate research efforts so that the projects support each other and are suitable to being drawn together in an approach to theory.

The great importance of the information issues and the current low level of public discussion of them encouraged the formulation of our third strategic principle, that research projects should be formulated in ways that help specify and assess policy options and their likely effects on the public. A corollary principle has been that the Program should not only produce conventional scholarly publications, but also material in a form useful and intelligible to the general public.

Our final strategic principle is aimed at assuring that the Program's work represents both intellectual independence and timely responsiveness to specific needs for knowledge. Thus, we have sought and continue to seek funding from multiple private and public sources and aim at a balance between general contributions to foster independence and project money that will make for responsiveness. This variety of funding methods will, we hope, forestall the complacency that can result from general funding and the servile hustling that project-oriented fund raising sometimes entails.

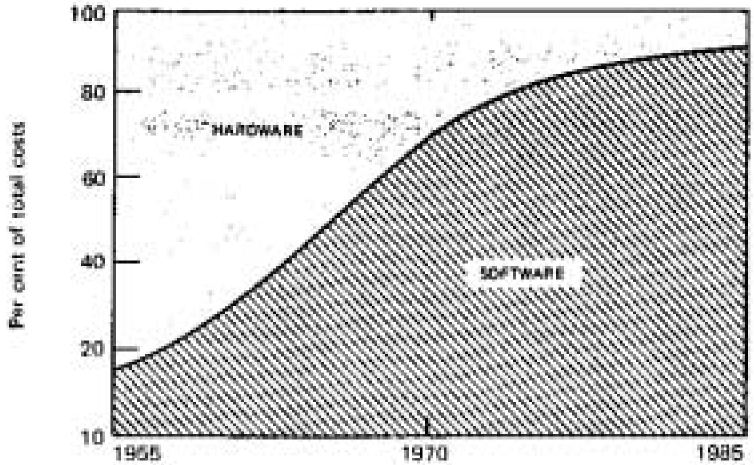

Figure 12. Hardware/software cost trends

Hardware/Software cost trends in computer systems show a pronounced shift toward a higher proportion of software costs. The tasks that any particular computer system actually does are specified only in part by how the physical system (hardware) is built. Programs of instructions (software) must be fed into the system to complete the specification. This complementarity (and, indeed, interchangeability) of hardware and software blurs the boundary between technology suppliers and the computer software supply industry, which we count among the information industries. The trend estimates are by Barry Boehm, in *Software and its Impact: A Quantitative Assessment*, RAND paper P4947, December 1972, p. 5.