Final Report

A STUDY OF TRENDS IN THE DEMAND FOR INFORMATION TRANSFER

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA

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PREFACE

This report describes the results of a study of demand trends in information transfer, performed by Stanford Research Institute for the Mission Analysis Division, Office of Advanced Research and Technology, National Aeronautics and Space Administration, Moffett Field, California. The research was conducted in the SRI Transportation and Logistics Department, of which Clark Henderson is the Director. The project leader was Roger W. Hough. Carolyn Fratessa, Virginia Holley, and Larry J. Wells were major participants in the study.

Substantial assistance in accomplishing the work was provided by members of groups outside the Transportation and Logistics Department. These included Elmer B. Shapiro, Information Science and Engineering Division, and Aryeh H. Samuel, Physical Sciences Division. Many other individuals also provided helpful suggestions at various points during the research, and Mr. Louis Feldner of Palo Alto provided consulting assistance during the latter part of the study.

The project team is grateful to Mr. Edgar M. Van Vleck, NASA Mission Analysis Division Technical Monitor, for valuable assistance and guidance as the study proceeded. A brief review and discussion of the research with Mr. A. R. Gregg Andrus, NASA Headquarters, and Mr. Sam Gubin, Goddard Space Flight Center, elicited many relevant comments and important considerations.

Assistance was also provided by a number of individuals outside of SRI. Principal among these were Messrs. H. J. McMains, William Quirk, and R. G. Hochstuhl, American Telephone and Telegraph Company, New York, New York; W. A. Cornell, L. R. Pamm, J. C. Ewin, R. L. Simms, Jr., and H. S. McDonald, Bell Telephone Laboratories, Holmdel, New Jersey; Paul Baran and A. J. Lipinski, Institute for the Future, Middletown, Connecticut; and Dr. Eugene Fubini, Consultant, Washington, D.C. We are grateful to each of these individuals and to the many other unnamed contributors for their assistance in performing the study.

Although information and advice was received from many sources, the findings and conclusions presented in this report are the responsibility of Stanford Research Institute.

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I INTRODUCTION

One of the most challenging assignments for the United States in the coming decades is the sorting out of the nation's communications capacities, capabilities, and needs. With the advent of communication satellites, computer networks, and new services of all kinds, and with a general and rapidly increasing demand for all types of information transfer, the nation faces as it never has before the prospect of radical changes in its communications patterns.

This report examines one aspect of this "communications revolution"--new services. The study was commissioned by the National Aeronautics and Space Administration as part of a series of investigations, described below, into information transfer via satellite. The present research does not concentrate on satellites, since it is an investigation of telecommunications needs and services without regard to the means of transmission. However, many of the services described could easily be provided by satellite. Other studies in the series consider this question.

The method used is one of identifying potential as well as present-day services, classifying them into major categories, then establishing quantitative estimates of message traffic occurring within a given time period.* In order to aggregate diverse services such as voice, video, and record and data transmission traffic estimates are converted to the common denominator of bits (binary digits). These are then summed to provide a composite picture of potential requirements for the future.

The study does not consider, nor do the conclusions imply, estimates of circuit requirements. While it would be possible to use the results of the research as a basis for such further analyses, considerably more effort, both in time and funding, would be required for such a study.

Background

In late 1968, the Mission Analysis Division of NASA's Office of Advanced Research and Technology issued a Request for Proposal concerning

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* The period of interest for the forecasts is nominally 1970-1990. The geographic area of interest is the United States.

an "Information Transfer Satellite Requirement Study." A portion of the work statement for this RFP read as follows:

> Technology has created an increasing need for the transfer of information in large quantities, at high rates, and with highly specialized requirements. Initial projections of this demand for information transfer services suggest that, in the future, advanced satellite systems may be needed to supplement terrestrial services. In order to identify the associated technology requirements of these potential systems, it is necessary to begin to identify the information transfer categories for which the future demand may be significant and the potential payoff promising.

Stanford Research Institute responded to this Request for Proposal, preparing a bid that dealt with each of the topics required. In the subsequent evaluation, the study was won by Lockheed Missiles and Space Company (LMSC) of Sunnyvale, California. However, in order to accomplish additional work on the subject matter, NASA contracted with SRI to do a portion of the original work in parallel with the LMSC study. This is the work reported in this document.

It is important to note that, while these were "parallel" studies, they were not intended to be equivalent in the sense of covering the same ground. The original request for proposal contained five tasks, of which the first was a "demand trend analysis." The other four tasks were

- Development of Functional Demand Catalog
- Development of Methodology for Operational and Economic Analysis
- Performance of Operational and Economic Analysis
- Refine Operation and Economic Analysis

Each of these five tasks is being addressed in the Lockheed study. However, only the first of the five, the demand trend analysis, is addressed in the present study. Thus, the research is more modest in scope, and has objectives and results that are considerably different from those of the "parallel" contract.

As indicated in the paragraph quoted above, an important objective of the research was to identify new technology. To accomplish this objective, NASA contracted with the Convair Division of General Dynamics Corporation for an "Information Transfer Satellite Concept Study." It was intended that the results of the Lockheed, and to some extent the SRI studies be used as input to the Concept study. The output of the latter, therefore, would include at least in part recommendations to NASA concerning new items of technology that might be relevant for consideration in NASA's overall program of communication satellite technology development.

In summary, the three studies were designed to complement one another. While each could stand alone--and they have all been conducted with that in mind--the major objective of the first two was to study requirements or demand for communications, whereas the third study is concerned more with the implementation of systems to supply that demand.

Scope

At the outset of this study it was clearly recognized that information transfer could be defined and characterized in many ways. We also became aware that such definitions would be crucial to the analysis. For example, it was known that NASA's original intention in using the term "information transfer" was to convey something broader than present-day electrical communication, understood for the most part to consist of telephone, telegraph, radio, and television. At the very least, consideration had to be given to an interpretation of information transfer that would include present day written communications such as postal services, newspapers, books, magazines, and other periodicals.

Recent events led us to consider as well certain aspects of computers, particularly the impact they are beginning to have as they are increasingly connected together via communication networks. Specialized satellites have been proposed, some of which are designed specifically and exclusively for the transmission of information. Examples of these are direct broadcasting, aeronautical communications and navigation, and data relay satellites.[1,2,3*] Other types of satellites generate large amounts of information in their own right using on-board sensors, including man. Earth resource satellites, manned space stations, deep space missions both manned and unmanned, weather satellites, and the entire series of unmanned experimental satellites all fall into this category.

Viewing these various aspects of the problem it became clear that one of the major advantages to be gained by this study--and one of the

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* References are listed on pages 69 through 71.

major departures from previous work--would be the development of a structure for viewing information transfer in its entirety. It was evident that more than traditional electrical communication activities should be assumed. For instance, what about broadcasting? Should it be assumed that we are concerned with the amount of intelligence falling upon many individuals collectively? Or would it be more correct to postulate an "information system" of some type, attempt to separate "inputs" from "outputs," and then, by suitable and appropriate assumptions, characterize and analyze those inputs and outputs?

Our conclusions on these points were as follows:

1. The intent of the task was to estimate demand for communications (or information transfer) with respect to an "information transfer satellite." Such a satellite was assumed to bear a strong resemblance to present-day communication satellites, which are of the relay or point-to-point type. This definition, it should be noted, does not limit the number of ground stations nor does it assume any limitations in the methods by which calls or messages are routed from one point to another. What it eliminates is the notion that the satellite we are considering may be either (a) a data collector, i.e., a point<u>s</u>-to-point device, or (b) a direct broadcast satellite, or point-to-point<u>s</u> device. Instead, we view the information transfer satellite as a relay, that may--indeed must, if we are to consider everything--be capable of relaying any kind of information, including information originally generated by data collection systems and information distributed by direct broadcasting satellite systems.

2. Because the notion of a communication satellite is in the "backs of our minds," it is not reasonable to consider information that is not transformable into electrical signals. The delivery of packages--i.e., physical matter--by satellite, however novel that idea might be, or even however feasible it might become at some future time, should not be considered in the analysis.

3. Although conversations between persons in the same room are communicable by electrical means, these should also be excluded from the study. That is, there is some minimum distance over which the information must be transmitted in order for it to be of interest to us, but this distance is not related to commonly derived break-even distances for

satellite versus terrestrial links.* Thus, the question is one of: Does it make sense to transmit the information electrically at all? rather than: Does it make sense to transmit it via satellite?

4. Finally, to generalize the problem as completely as possible, we conceive of a "total U.S. information system." We liken this to a black box into which all information flows from the input devices, and out of which all information flows to the output or distribution devices.

   A communication or information transfer satellite may or may not be part of this system. We neither presuppose such a transmission method, nor do we exclude it, being concerned in this study only with potential traffic demand in the aggregate, not with some portion that may be amenable to satellite transmission.

As a result of the preceding analysis, the scope of the research may be summarized as follows:

- Consider items of information that could conceivably be transmitted electrically or electronically--voice, video, facsimile, telegraph messages, data, and so on.
- Concentrate on domestic U.S. rather than international traffic.
- Concentrate on point-to-point service.
- Consider data collection and broadcasting services only as they affect point-to-point service.
- Consider <u>all</u> forms of information transfer, including new services as well as present ones, subject only to the constraint that the information must be transformable into electrical signals.

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* It has been noted on a number of occasions that such distances may vary greatly, depending on the assumptions used in the calculations; thus, the desire to derive results that are independent of such calculations.

Having defined the basic nature of the study, it should be noted that in contrast to more conventional traffic studies--particularly those that deal with circuit requirements--the present study is of more limited scope. We approach the problem in "bulk," so to speak, without performing any queuing analysis, peak volume calculations or any other of the necessary steps required to satisfy more detailed analyses. The basic purpose of the three studies taken together was to develop some quantitative basis for selecting certain information transfer services or missions that show more promise than others for satellite application. The present research considers this objective only insofar as potential information transfer volume is concerned.

II SUMMARY

Method of Approach

The method used to analyze trends in demand for future communications was the following. First, an extensive list of existing or potential information transfer services--voice, video, record and data transmission, and written material--was assembled from literature sources and SRI files. Second, sample services were selected from the list on the basis either that something was known about the service (that is, it was not a completely new service), that it was a particularly interesting service that might shortly come into use, or that it looked as though it might become important if it were to become an established service. Examples of these three are telephone, videotelephone, and telemail services, respectively.

The third step in the study procedure was to determine for each of the selected services a projection variable that bore some relationship to the amount of information transferred; for example, number of calls, messages, or transactions; or hours of operation per unit time period. Preferably, this variable would itself be represented by a historical series--e.g., average daily calls are directly related to telephone service. On the other hand, the variable representing information transferred might only be relatable to another series. For example, airline reservation requests are assumed to be correlated with airline passengers. In any event, the choice made was such that (a) an acceptable projection variable was established, and (b) that variable bore a predictable relationship to another variable that expressed volume of information transfer.

In performing the trend analyses, use was made of the method of "historical analogy" as well as simple trend extrapolation. For some services, notably videotelephone, no acceptable historical pattern yet exists. In those cases, reference was made to early growth patterns--logistic curves--that characteristically have in their early stages rapid rates of growth, which then decline to fairly constant levels over the long term. Evidence was taken from the early growth records of automobiles, television, telephone, telegraph, and other technological developments to support those analyses.

The final procedure in the demand trend analysis was to convert all calls, messages, transactions, and the like to a common denominator such that demand for the various services could be added together, summarized into appropriate higher level categories, and so on. The expression chosen for this common denominator was bits (binary digits) per year. The method of conversion entailed first an assumption about the information transfer mode most likely to be used for the service--voice, video, alphanumeric coding, standard facsimile, high quality facsimile, and so on. Next, a standard conversion method was assumed for each mode of operation, such as 30,000 bits per page for alpha coded text, 64,000 bits per second for voice (assuming conventional PCM coding), and 180 megabits per page for high quality newspaper facsimile. Finally, these factors were applied to the volume of transactions that had been projected for the various services. The result, then, was a statement of potential information transfer volume expressed in all cases in bits per year.

Quantitative Results

The major findings of this research, which are summarized in Figure 1 and Table 1, concern the maximum amount of electrical or electronic information transfer that might reasonably be expected in the following categories: voice; video; record, data, and private wire; and written.* In all cases the findings represent amounts of information that might be input to a conceptual "black box" information system--specifically in this case a connected, U.S. information network. Retransmission of the information by broadcasting it to many viewers or subscribers simultaneously is not included.

A brief description of the basic types of information transfer that are included in the above summary is given in Table 2.

Particularly relevant features concerning this overall statement of potential demand include the fact that both video and record-and-data transmission are growing--and can be expected to grow in the future--considerably faster than voice communications. For example, video communications are shown at a projected compound annual growth rate of 35 percent, while data communications are projected at approximately 25 percent growth per year. By contrast, voice communications are projected at only 8 percent per year. Because the intent of this portion of the

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* The last category includes books, magazines and other periodicals, newspapers, and mail.

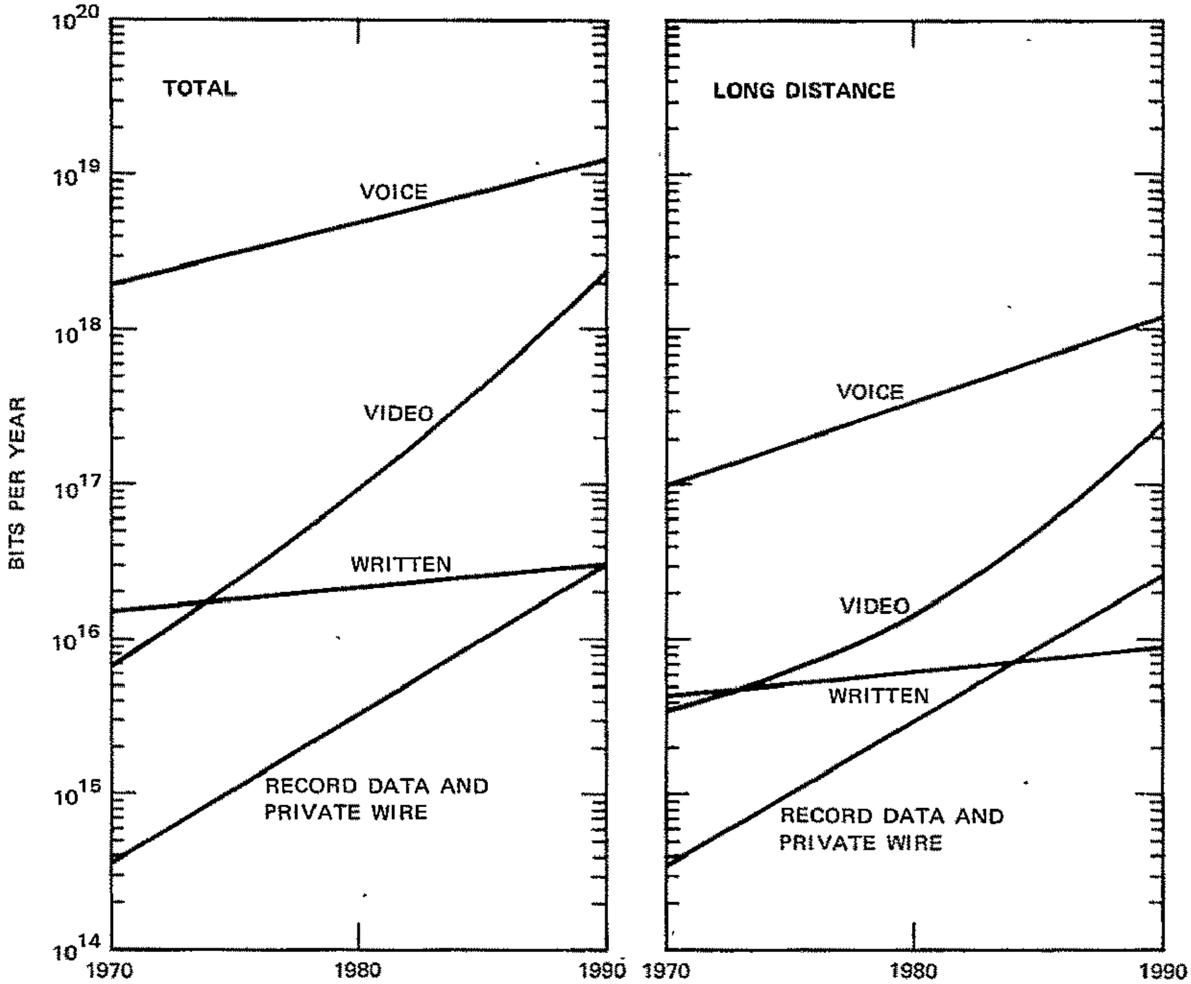

FIGURE 1 PROJECTED INFORMATION TRANSFER VOLUME, 1970-1990

Table 1

PROJECTED INFORMATION TRANSFER VOLUME, 1970-1990
(Bits per Year)

	1970		1980		1990	
	Total	Long Distance	Total	Long Distance	Total	Long Distance
Voice ($\times 10^{17}$)	20	1.0	50	37	100	10
Video ($\times 10^{16}$)	0.56	0.33	9.0	1.5	230	25
Record, data, and private wire ($\times 10^{15}$)	0.38	0.34	3.5	3.1	30	27
Written ($\times 10^{15}$)	15	10	20	14	30	21

Table 2

CLASSIFICATIONS USED TO SUMMARIZE RESULTS
OF THE STUDY

Voice Telecommunications

- Telephone
- Mobile Radiotelephone
- Radio Program Transmission

Video Telecommunications

- Videotelephone
- Closed Circuit and Other Special Television Services
- Television Program Transmission

Record, Data, and Private Wire Communications

- Public Message Telegraph
- Teletype Service (TWX and TELEX)
- Data Transmission
- Private Wire Systems

Written

- Books and Magazines
- Newspapers
- Mail

study was to determine maximum potential demand for the newer services, the precaution was taken to "err on the high side"; this counteracts the common tendency to underestimate in long range forecasting. Nevertheless, of the several categories, it appears that data communications might still be underestimated due to the difficulty of enumerating all possible applications. Video communications volume may also be larger than shown, if estimates of video-telephone service are found to be conservative.

In contrast, the estimates given for written communications--that is, electrical transmission of inherently written material--are probably high. Because potential demand for information transfer is shown rather than forecasts of actual demand, the amount shown in this category includes all present day first class and airmail, as well as transmission of whole books and newspapers to remote printing plants.

Estimates of voice communications are based on reliable and very regularly increasing statistical data. Thus, this projection may be characterized as probably the least subject to error. However, for a number of years the potential for greatly increased mobile telephone service has been apparent. This has been hampered primarily by demands on the radio spectrum in the bands authorized for such service by the Federal Communications Commission. If, during the period of time covered by the study, mechanisms are established by which many more users could be served by mobile telephone service, the estimates for voice communications may also turn out to be conservative.

Discussion

As shown in Figure 1, the amount of information transfer represented by voice communications may be expected to exceed that in all other categories by a considerable margin. This conclusion contrasts markedly with the popular and widely held view that "volume of data will be half that of voice sometime in the seventies."

The reason for this apparent contradiction lies in the fact that different assumptions have been made in the past regarding the number of bits represented by voice conversations. One of these assumptions is based on the speed of a "human channel," which is about 180 to 300 words per minute.[4] Removing redundancies in the voice and in the language reduces this to about 40 bits per second. Thus, in the past some statements about voice versus data have assumed this conversion factor for voice. Alternatively, a conversion factor of 2000 bits per second has been assumed. This rate represents the approximate digital transfer rate that can be achieved on a typical voice circuit without special conditioning of the line.

The assumption made in this study is that the most appropriate conversion factor to assume for an overall comparison such as the present one is 64,000 bits per second. This figure represents the current method of physically coding voice into a digital bit stream, assuming pulse coded modulation (PCM).[5] Limitations of this assumption are discussed later in the report, under Conversion to Bits per Year, Chapter IV.

Appendix A of this report is a list of approximately 400 potential information transfer services that were compiled for the study from references in the open literature, SRI files, and discussions with participants in the study and with other interested parties. As explained in the introduction to the Appendix, the list represents possible developments only; we have not attempted to evaluate the likelihood of the actual development of any of them. In the list we show the major characteristics of each service as a function of the following parameters:

- Analog or digital
- One way or two way
- Low speed or high speed
- Real time or delayed transmission
- Primarily local or primarily nonlocal usage

Appendix B is a discussion of two proposed satellite mail systems, presented as an example of the possible implementation of one of the many services discussed in this report.

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* This fact was brought to light in private conversations with members of the staff at Bell Telephone Laboratories.

III THE ECONOMIC FRAMEWORK

Demand Trend Analysis

The traditional economic tool for demand trend studies, and the method used here, is time series analysis. In their simplest form, time series are represented by plots of the value of a given variable versus time. The variable may be anything at all that has a value at different points in time, such as revenue, miles of wire, number of telephones, population, gross national product, and so on.

Very often, graphs of such variables may be approximated by straight lines on semilogarithmic paper--that is, graph paper having a linear scale on one axis and a logarithmic scale on the other axis. In such cases, the activity represented by the variable is said to be growing or declining at a constant compound annual growth rate. Long term trends such as population and gross national product are typical variables having straight line growth curves, each having exhibited fairly constant rates of growth for many years.

Rates of growth are of interest in studies such as the present one because they provide a means for forecasting future trends. This, in fact, is by far the most commonly used technique in long range forecasting. It is also the most convenient and economical method, requiring no more than a plot of the historical data for the series of interest and a straight line projection (if the data warrant it) into the future.

There are, however, many important limitations in projecting constant rates of growth. One of these results from the fact that many products and industries go through a "life cycle" that is characterized by <u>increasing</u> rates of growth in early history and by <u>decreasing</u> rates of growth as maturity is approached.[6] In these cases, a plot of the growth variable resembles an "S-shaped" curve, which is characteristic also of biological growth. Such curves are commonly called "logistic" or "Gompertz" curves.* Characteristically, they have an introductory

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* Mathematically, the Gompertz curve is a special case of the logistic curve. It is most applicable to the growth of products that have shorter introductory periods and that approach maturity more gradually than products represented by logistic curves.

period (the bottom of the "S") during which absolute increments of growth are small, followed by a period of rapid absolute growth, followed by an approach to maturity during which absolute increments of growth are again small.

For the present study, the fact that products and groups of products exhibit such "life cycles" is very important. For example, one of the required tasks of the study was to estimate demand for information transfer services that have not yet come into being. Traditional trend projection methods are of little value in this case, because historical data are completely lacking.

To provide a solution to this problem, a technique called the method of historical analogy was borrowed from the field of technological forecasting.[7,8] This method allows one to use information from past historical developments and apply it to future events of a similar nature.

A considerable amount of data is available for such purposes in the field of communications. As shown below, telegraph service began in the United States in 1867, and telephone service in 1876. Each of these services experienced rapid growth in its early stages, followed by declining, then constant rates of growth. In the case of telegraph service, an absolute as well as a relative decline has been experienced, in contrast to telephone service, which has continued to increase at a constant rate since 1933.

Historical Growth Patterns of Selected Technological Developments

The Telephone

The history of telephone service in the United States is shown graphically in Figure 2. Both number of telephones and number of conversations are plotted in the figure to illustrate the close correlation between the two series. There are many interesting features about these curves, not the least of which is their sensitivity to the general economic climate. It is easy to recognize, for example, the marked decline in both series between 1930 and 1933; the abrupt and continuous recovery after 1933; the clear but less pronounced decline (in conversations) during World War I; and the decreased rate of growth--though not an absolute decline--during World War II.*

* Another interesting fact is that, despite the rapid recovery after 1933, neither series regained a position equal to what it would have

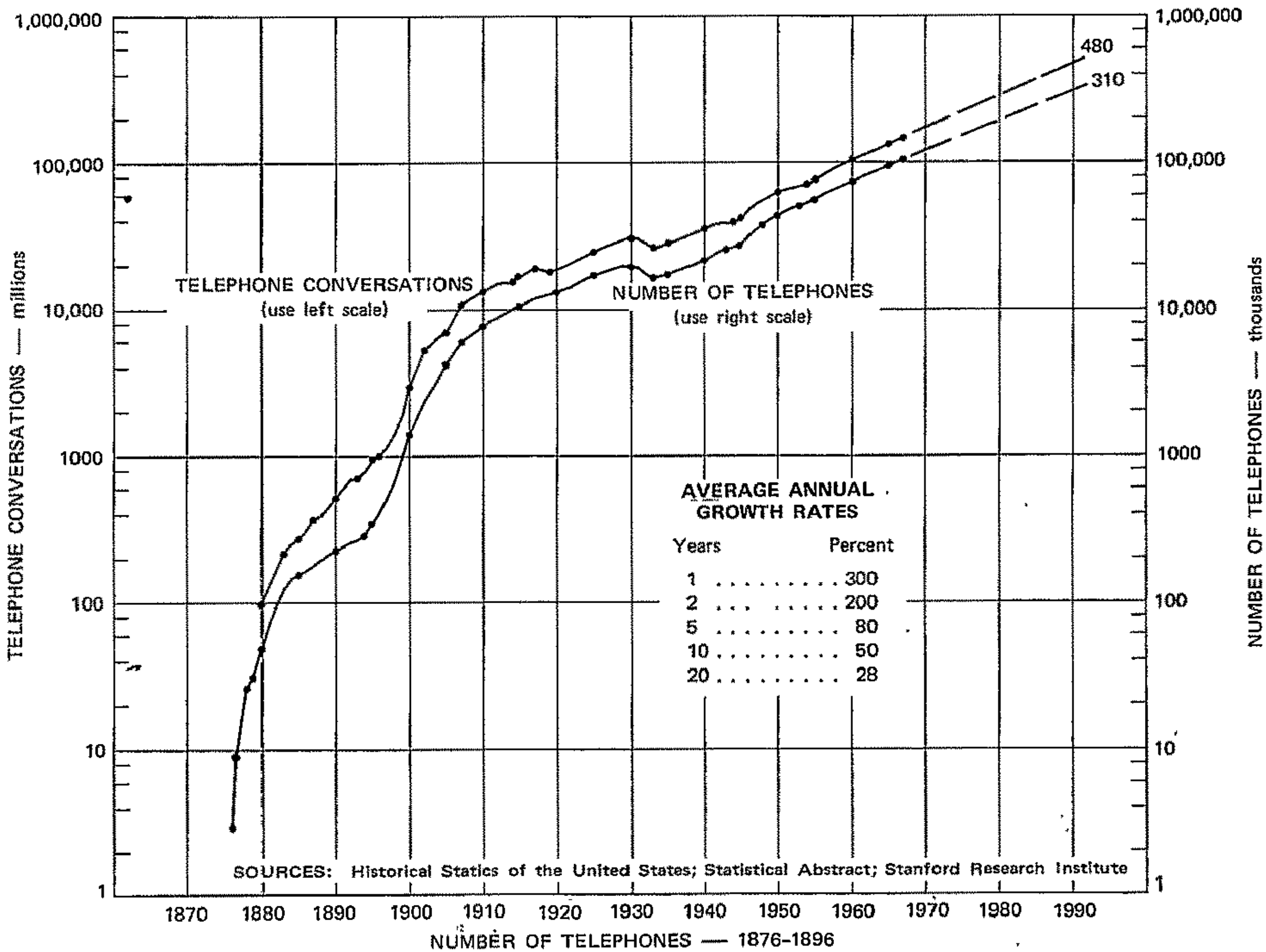

FIGURE 2 U. S. TELEPHONE GROWTH, 1876-1970

Of more interest to us here, however, are the overall growth rates and the growth rates at the very early stages of the service. As may be seen, the growth patterns of both series exhibit portions of the "life cycle" phenomenon mentioned earlier, i.e., rapid rates of growth in the early stages of the service, followed by declining, then constant rates of growth at later stages. However, neither curve resembles an "S-shape"--that is, an increasing rate of growth at the beginning of the service does not appear.

This is borne out in the calculations of early growth rates shown on the figure. In the first year of operation (1876) 3,000 telephones were installed, and in the second year the figure was 9,000 telephones. Thus, between the first and second years (shown in the chart as "Year 1"), the increase was 300 percent. Similarly, for the first two years of service the increase was 200 percent per year. For the first five years of service the average annual growth was about 80 percent per year; for 10 years, it was 50 percent per year; and for 20 years, 28 percent per year.

From these statistics it appears that telephone service had little or no "warmup" period in the United States. It began quickly and maintained a reasonably high, though continuously declining rate of growth throughout its first twenty years of life.

Telegraph Service

There is quite a difference between the history of telephone service and the history of telegraph service, which is illustrated in Figure 3. The most obvious characteristic of this series is, of course, its absolute decline in recent years. Since 1945, when 236 million telegrams were sent, the service has declined approximately 4 percent each year. In 1966 only 93 million messages were sent; if the trend continues 80 million will be sent in 1970, and about 53 million will be sent in 1980.

Despite this decline, when the service was inaugurated in 1867, it, too, experienced the characteristic life cycle of faster growth at the

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been had the country not experienced the Great Depression. For example, if calls had continued to increase at 5 percent per year from 1930, rather than from 1933, 250 billion calls would be made in 1970, instead of 170 billion.

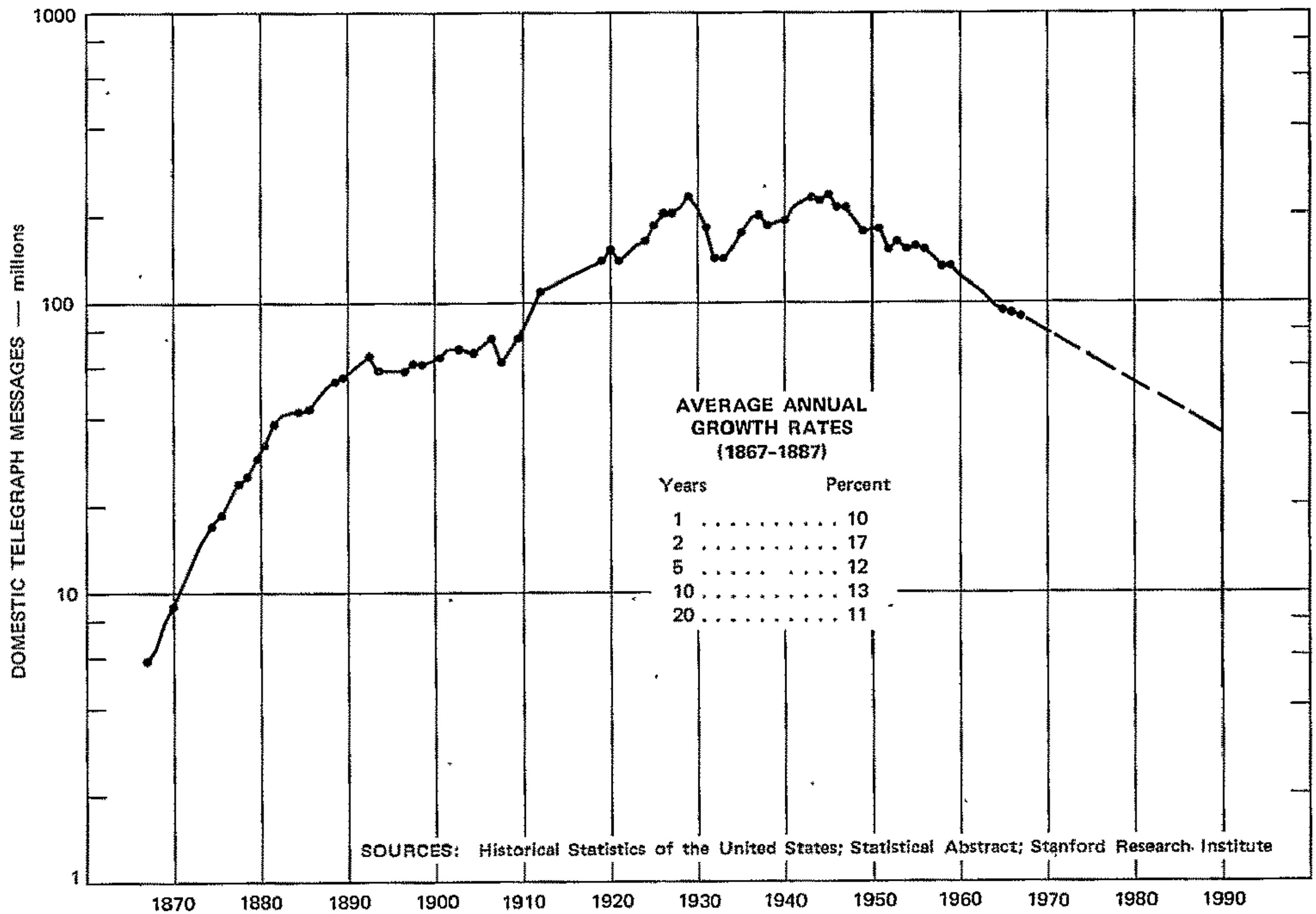

FIGURE 3 U.S. TELEGRAPH SERVICE, 1867-1970

beginning, then fairly constant growth over an extended period. Telegraph service was never accepted to the same degree as telephone service, however, having grown at most about 17 percent per year and averaging about 11 or 12 percent for the first twenty years.

Television

Of the six technological developments illustrated in this chapter, the history of television, shown in Figure 4, exhibits the most regular as well as one of the highest growth rate patterns. Receivers installed grew by more than one thousand percent in the five year period 1946 to 1951, resulting in an average annual growth rate of about 320 percent per year during that period. For the first ten years the average annual growth rate of the series was 190 percent per year, and at twenty years the overall rate was still almost 60 percent.

The growth of television illustrates well the phenomenon of pentup demand. The service was inaugurated immediately after World War II when the demand for all consumer goods was high. It had been demonstrated as technologically feasible many years before. It was a clearly obvious improvement in communications, being much more graphic and forceful than radio, its nearest counterpart. What is remarkable, of course, is the regularity of the series, and the fact that it exhibits all of the technical details of a theoretical growth curve, including the period of increasing rates of growth at the beginning.

Microwave Radio, Automobiles, and Computers

The last three growth histories illustrated are miles of microwave radio relay installed by the communications common carriers, automobiles in the United States, and computer installations in the United States. These are shown in Figures 5 to 7, respectively. In each of these cases growth proceeded rapidly from the beginning, and at almost constant rates throughout the periods illustrated.

Rates of early growth for the three developments are quite different, however. In the case of microwave radio relay, for example, overall growth for the first twenty year period was about 24 percent per year. Early growth of the automobile, by contrast, took place at about 40 percent per year for the first twenty years. Since computers were first introduced commercially in 1951, a twenty year history has not yet been compiled. However, as shown on the chart, this development has indeed

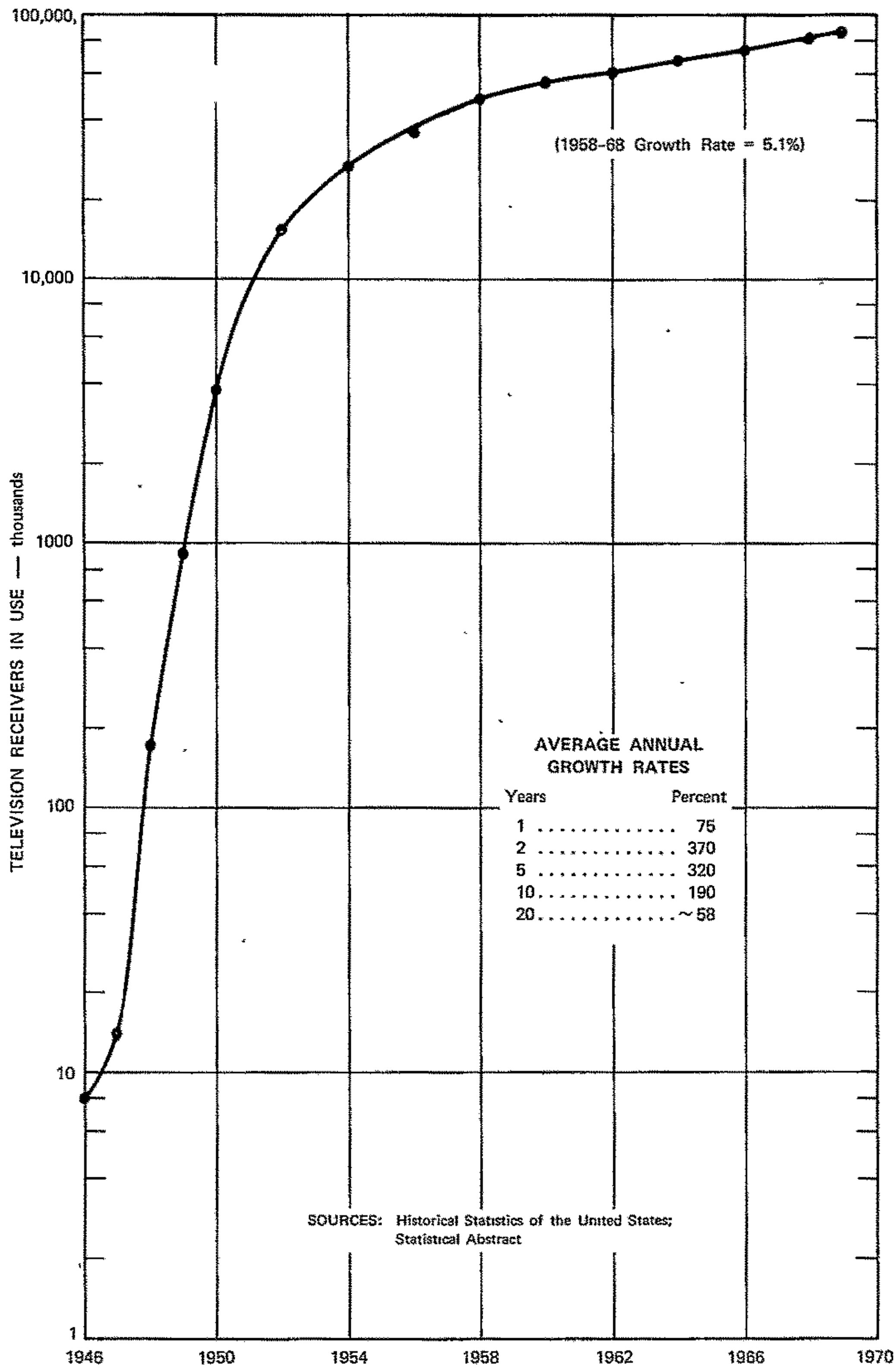

FIGURE 4 GROWTH OF TELEVISION IN THE UNITED STATES

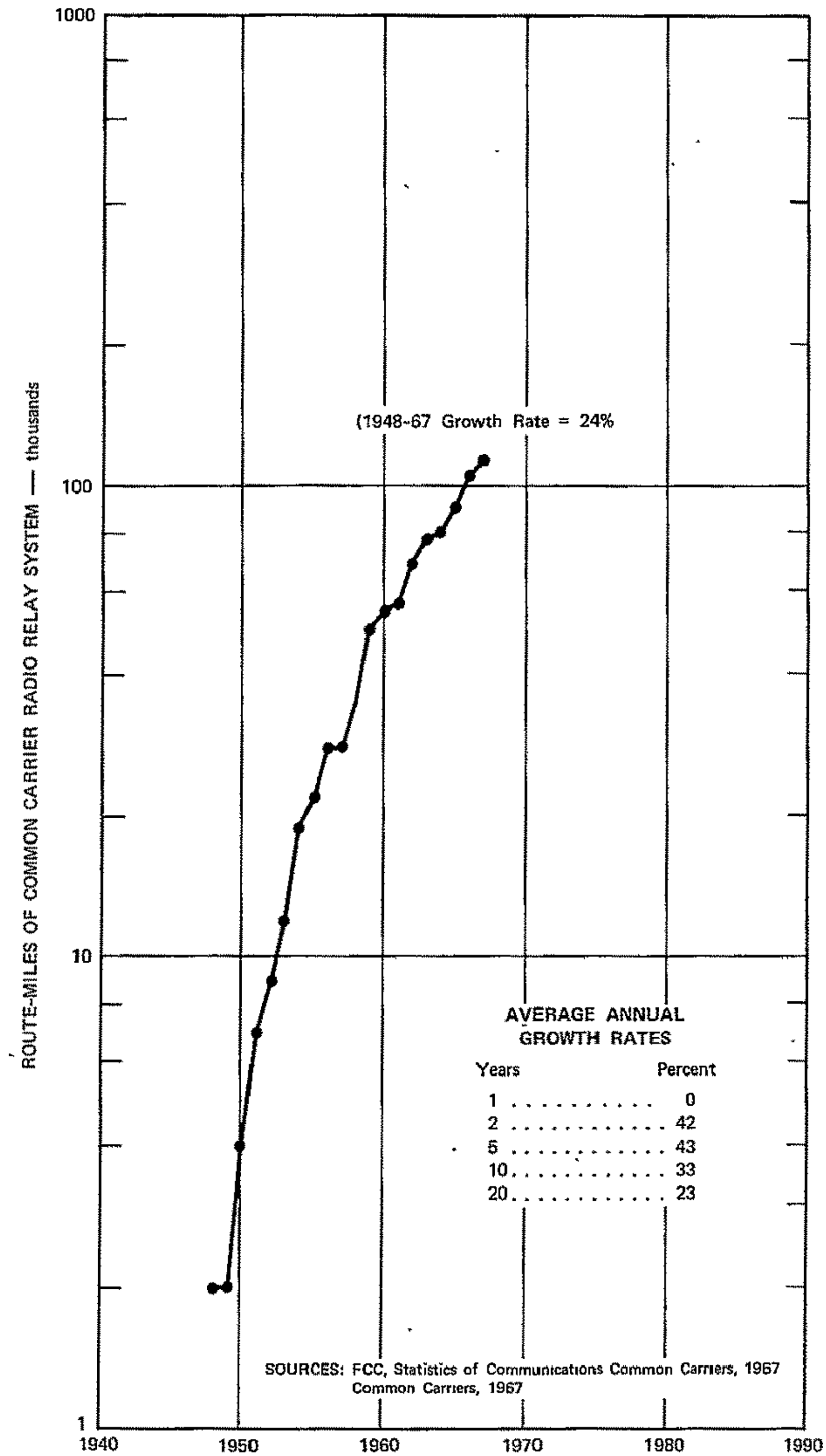

FIGURE 5 GROWTH OF MICROWAVE RADIO RELAY IN THE UNITED STATES

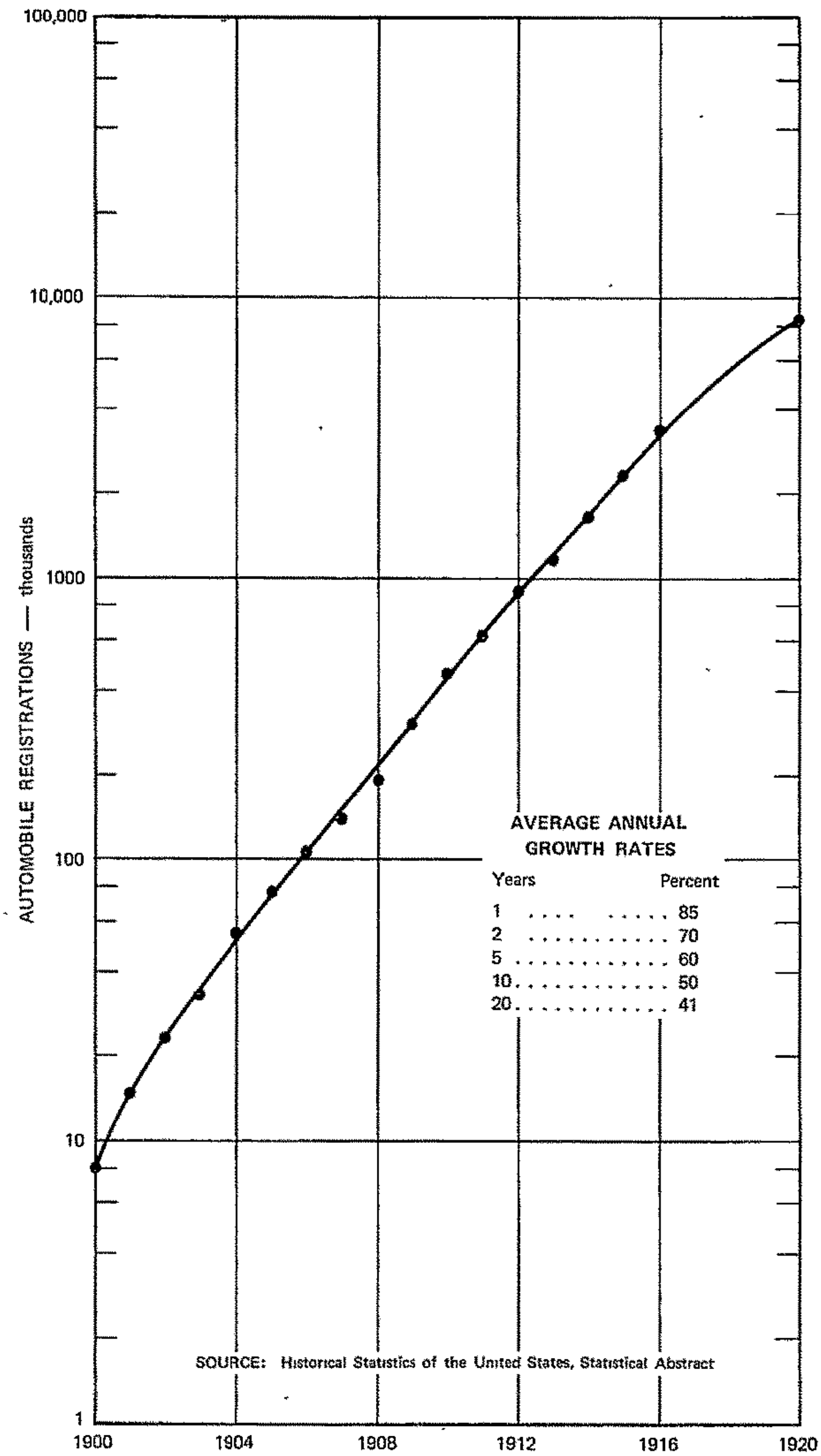

FIGURE 6 EARLY GROWTH OF THE AUTOMOBILE IN THE UNITED STATES

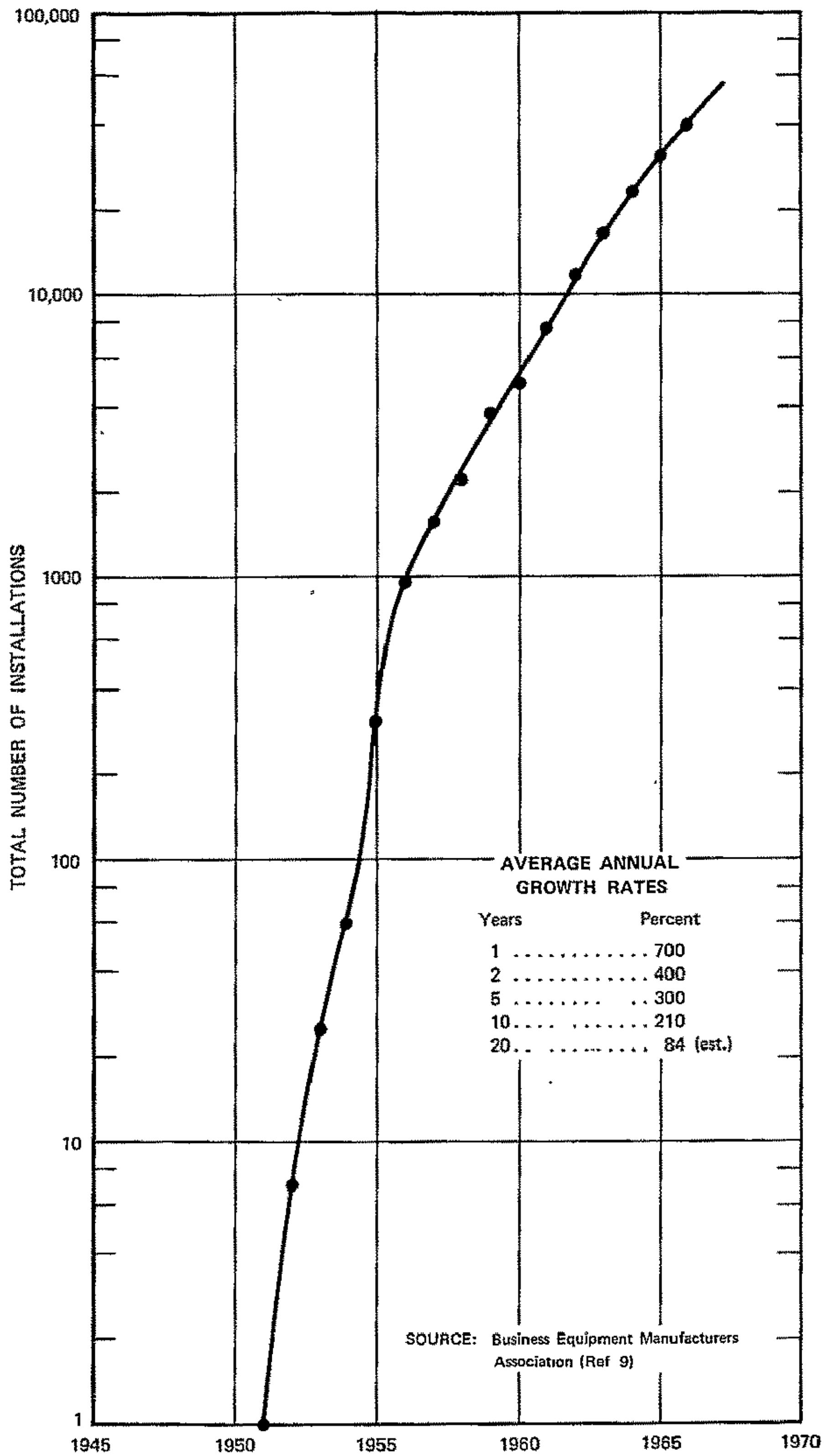

FIGURE 7 GROWTH OF COMPUTERS IN THE UNITED STATES

had an explosive history, if the number of computer installations is accepted as a reasonable measure of growth.

Between 1951 and 1952 the number of computers in the United States increased by 700 percent. For the first two years the growth rate was 400 percent per year. At five years it was 300 percent; at ten years, 210 percent; and, extrapolating to 1971, at 20 years it will be 80 to 85 percent overall.

Summary

The growth trends presented in this chapter are summarized in Table 3. These trends give a clear picture of the manner in which the growth of new developments has actually taken place in the past. In the next chapter this evidence is used to provide a basis for projecting new services that have no historical base at the present time.

As mentioned earlier, the technique used is the method of historical analogy. This technique has been described elsewhere as a "qualitative" method of forecasting.[10] In the present study, however, it seems reasonable to conclude that even the quantitative implications of past growth trends may be useful. Thus, we take note of the different rates of growth in Table 3, and make the assumption that, for certain developments clearly on the horizon, growth is likely to proceed at rates somewhat akin to those experienced in the past. This is the assumption that is applied in the next chapter.

Table 3

AVERAGE ANNUAL RATES OF EARLY GROWTH
FOR SELECTED TECHNOLOGICAL DEVELOPMENTS

	Years	Growth Rate (percent) First Year	First 2 Years	First 5 Years	First 10 Years	First 20 Years
Telephone	1876-1896	300%	200%	80%	50%	28%
Telegraph	1867-1887	10	17	12	13	11
Television	1946-1966	75	370	320	190	58
Microwave	1948-1968	0	42	43	33	23*
Automobile	1900-1920	85	70	60	50	41
Computers	1951-1971	700	400	300	210	84*

* Estimate.

Source: Stanford Research Institute.

IV DEVELOPMENT OF DEMAND PROJECTIONS

The major quantitative results of this study were derived by considering approximately thirty individual information transfer services in such a way as to estimate potential information transfer demand volume, local, nonlocal, and total, in terms of bits per year. This was accomplished by selecting a representative sample from the list of services in Appendix A; determining a projection parameter for each service based on number of calls, messages, transactions, hours of operation, and so on; projecting this variable over the time period of interest; and then converting all demand to the common denominator of bits per year of potential information transfer.

The figures in this chapter give a part of the basic information and illustrate the methodology. Two types of services are illustrated--those that have historical data associated with them and those that do not. Projections are made, either from historical data as shown on the figures, or by analogy to the beginning period of similar services.

As described in the previous chapter, a critical part about early growth curves is the fact that the rate of growth declines as the period of service increases. While it is possible to illustrate this phenomenon with historical data, it is somewhat misleading to attempt to forecast the precise shape, points of inflection, and rates of change in future growth curves if no historical data at all are present. For this reason we have chosen to apply the approximate rates of growth of analogous services for the first twenty years of their lifetimes to those services, such as videotelephone, that have no historical base at the present time. A simple exponential trend line (a straight line on semilog paper) has been used to make this approximation. It should not be inferred that we expect the growth to proceed exactly in accordance with the simple trend line given in these cases. In all probability the growth curve will have, as it has had in the past, first an increasing and then a decreasing slope.

The projections given in this chapter do not in all cases imply "real" demand for information transfer, even after the conversion to bits per year. What they imply is simply <u>potential</u> demand. Thus, no attempt has been made to predict time scales for development of new electronic services to replace present-day nonelectronic means of information transfer, and the actual development of such services is not implied.

Telephone

For the purpose of extrapolating into the future, more data are available for telephone service than for any other. Statistics have been collected since the beginning of the service in 1876; and at an early date separate records were started for long distance, business and residential use, and for revenues by type of service. Furthermore, as shown in Figure 4, both the numbers of telephone instruments and telephone conversations have been increasing at a constant rate (about five percent per year) for many years.

For a number of reasons, some forecasters in the past have taken the position that this rate of increase must decline before too many more years pass. They say, for example, that it is impossible to talk on the telephone more than X number of minutes per day; and since conversations are increasing faster than people, saturation must begin to take place soon. As a matter of fact, projections have been made in the past that assumed saturation, only to find that it did not occur. Although U.S. telephone conversations per person per year reached 667 in 1967,[11] this is still less than two per day per capita on the average. Without a doubt most business and professional men, and probably housewives also, make more calls than two per day. Thus, there is little reason to suppose on these grounds--that is, saturation--that the rate of increase either of telephones or of conversations will decline in the next twenty years.

Another factor, however, is considerably more important. That is the substitution of videotelephone for voice telephone conversations. Past history shows clear examples of such substitution, and the exchange of videotelephone for voice-only telephone may very likely take place sometime in the future. We would expect, therefore, to see a gradual decline in voice conversations as videotelephone service becomes accepted.

The matter of substitution, however, is not dealt with quantitatively in this study. For this reason, telephone conversations are projected at present rates of increase. Table 4 indicates the series for local, long distance, and total calls, including average annual rates of increase for various years. Over a span of five years or more, both local and total calls exhibit average annual growth rates of about 5 percent per year. Long distance calling is growing faster, however, especially in recent years. Taking account of this, we have projected an increase in long

Table 4

TELEPHONE CONVERSATIONS

Annual Number of Conversations (billions)

Year	Total	Local	Long Distance
1950	64.3	61.6	2.7
:			
1955	77.8	74.9	3.2
:			
1958	92.2	88.4	3.8
1959	97.5	93.4	4.1
1960	104.2	99.8	4.4
1961	108.4	103.8	4.6
1962	115.5	110.6	4.9
1963	120.0	114.8	5.2
1964	126.0	120.3	5.7
1965	134.2	128.0	6.2
1966	142.2	135.3	6.8
1967	148.2	140.8	7.4

Average Annual Growth Rate

1950-67	5.0%	5.0%	6.2%
1962-67	5.1	4.9	8.6
1962-63	3.9	3.8	5.8
1963-64	5.0	4.8	9.3
1964-65	6.5	6.4	9.6
1965-66	5.9	5.7	10.0
1966-67	4.2	4.0	8.5

Source: Reference 12.

distance conversations of 8.5 percent per year from 1970 to 1990, as shown in Figure 8.

As an aside, in the lower portion of the same figure we show a projection from past data that might have been made in 1964. At that time, long distance calls had not begun their steeper climb, and were growing at a rate of 6.5 percent rather than 8.5 percent. Undoubtedly, by following the same techniques used here one would probably have forecast future growth at the lower rate. A second speculation moreover, and one that is more interesting is the temptation to try to "explain" the increased rate of growth by, for example, decreases in the cost of long distance calls. Table 5 shows some typical decreases in long distance rates over the past forty years.

Table 5

LONG DISTANCE RATES

	From New York to: (dollars)*			
Year	Philadelphia	Chicago	Denver	San Francisco
1930	$.50	$3.00	$6.00	$9.00
1935	.50	2.50	5.25	7.50
1940	.45	1.90	3.25	4.00
1945	.45	1.75	2.35	2.50
1950	.45	1.55	2.20	2.50
1955	.50	1.50	2.20	2.50
1960	.50	1.45	1.80	2.25
1965	.50	1.40	1.70	2.00
1970	.50	1.40	1.60	1.75

* Station-to-station, daytime, three-minute call.

Source: Reference 12.

Within the last several years, tariffs allowing calls during certain hours of the day to any point in the country for one dollar or less were put into effect. An analysis might, therefore, show a relationship between such decreases and the increased number of calls. Many other

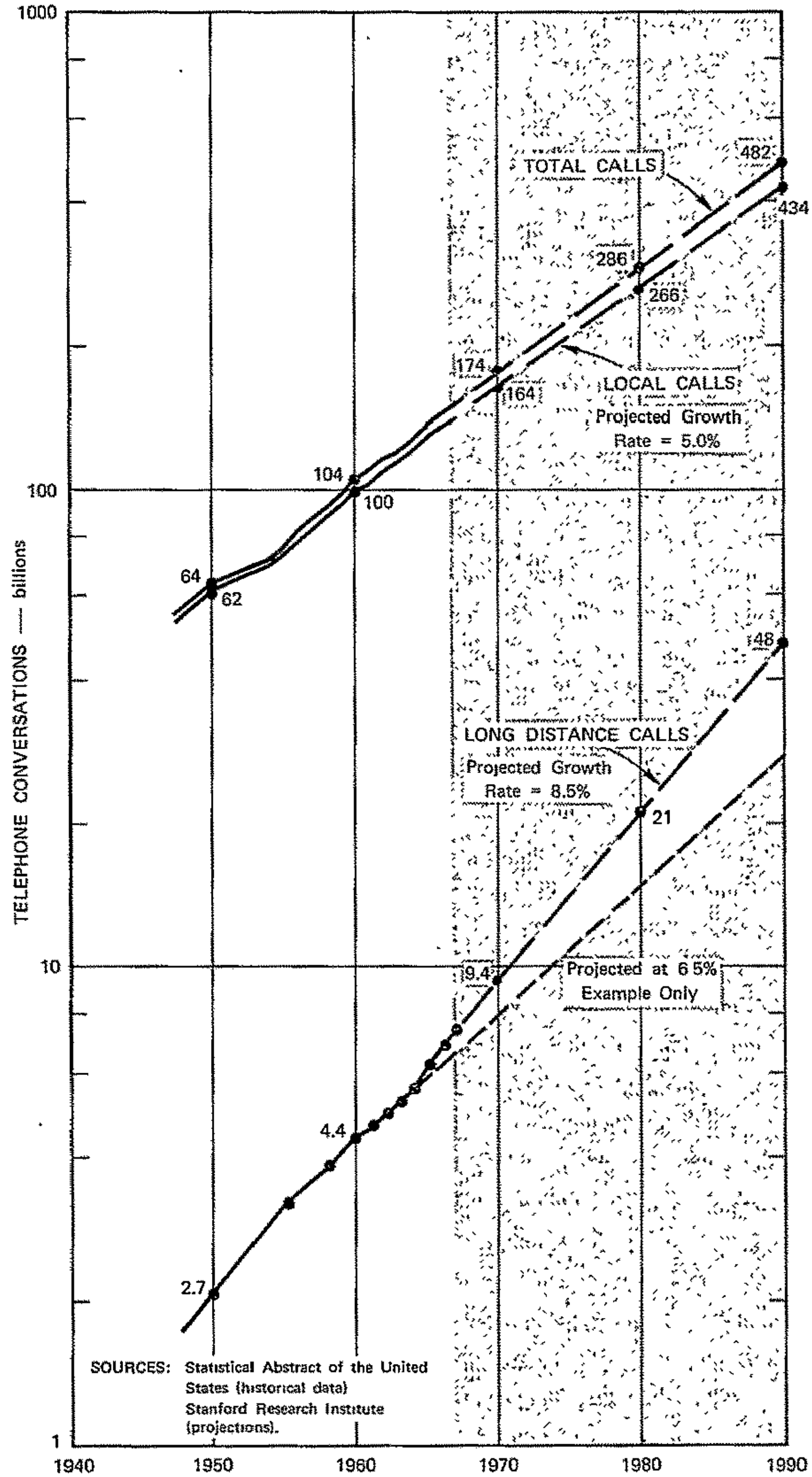

FIGURE 8 TELEPHONE SERVICE

exogenous events were occurring at the same time, however, including unprecedented gains in all business activities. Furthermore, the increases in 1964-67 may have been a continuation of the pattern from 1958-60, with the slight decline between 1960 and 1964 corresponding to the business recession of 1962. All this is, of course, speculation. But, it points out the added complexities of attempting to explain the reasons for growth and decline in demand trends for telephone service, while at the same time illustrating why such analyses are not included in the present study.

Videotelephone

In the remaining services, many more assumptions will be made than for telephones. Most of these, such as videotelephone or Picturephone* have not yet begun as offered services. Consequently, there are no historical data upon which to base a projection or forecast.

To provide for the lack of directly usable data, in the following service descriptions we rely upon either of two devices: (1) historical analogy to a similar service or (2) correlation to another, corresponding variable that does have a predictable nature.

In the case of videotelephone a natural analog is the telephone itself. Both instruments perform the same basic function, that is, to provide communication on a person-to-person two-way real time basis, and to provide it within the framework of a switched network such that anyone subscribing to the service may communicate with any other subscriber. A further analogy is the fact that these are personal services--the two subscribers can either hear or see-and-hear each other, lending a great attraction to this type of communication and distinguishing it in kind from written communications.

According to recently published information,[13] Picturephone service is soon to be introduced on a regular basis in several cities. Thus, we take 1970 to be the beginning year of the service. During experimental tests in 1968 and 1969, 40 sets were used at Westinghouse Electric Corporation, communicating regularly between New York and Pittsburgh.[14] In addition, some 60 sets have been in use within the Bell System for several years, making a total of about 100 sets in operation now, on an experimental basis.

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* Registered trademark of the Bell System.

In 1876, the first year of operation of the telephone system, there were 3,000 telephones in service.[15] Also, since 1880, calls per day per telephone have consistently averaged between four and eight, and the greatest number of calls per day occurred during the earliest years of telephone service, as indicated in Table 6.

Table 6

CALLS PER DAY PER TELEPHONE
1880-1970

Year	Calls per Day per Telephone	Year	Calls per Day per Telephone
1880	4.9	1930	4.1
1885	4.8	1935	4.4
1890	6.3	1940	4.5
1895	7.5	1945	4.0
1900	5.8	1950	4.0
1905	5.2	1955	3.6
1910	4.7	1960	3.8
1915	4.2	1965	3.9
1920	3.9	1970	4.0 (est.)
1925	4.0		

Using these guidelines we establish the following and in our view conservative assumptions:

1. During the first year of operation, approximately 1,000 video-telephones will be installed.

2. Each subscriber will place on the average four calls per day, making a total of about 1.2 million calls per year.

3. Calls will increase at an average annual growth rate of about 40 percent between 1970 and 1990. This is based on assumptions of "higher standards of living and income; the increasing share of economic life that is carried on by market transactions; the rising mobility of individuals and families; and the population

shift to the cities where people, even though physically closer, are less likely to meet face-to-face."[16] This rate falls approximately half-way between that for telephone and television in the first twenty years of their existence (28 percent and 58 percent, respectively) and is slightly less than that for the first twenty years of the automobile, at 41 percent growth per year. (See Table 3, p. 24.)

Consolidating these assumptions, we plot projected videotelephone conversations in Figure 9. Note again that, as mentioned earlier, the straight line does not imply that growth will take place precisely in the manner indicated. Rather, one would expect a pattern similar to the S-shaped or portions of S-shaped curves exhibited in Figures 2 to 7. Because it is speculative to attempt to forecast these changing rates of growth, we portray only the estimated growth rate at twenty years, leaving to the reader the option of estimating the real pattern.

Network Television Transmission

Statistics of the Communications Common Carriers[17] prepared annually by the FCC, contains radio and television broadcasting data that only relates to (1) revenue from audio and video program transmisstion and (2) miles of video carrier channel. Primarily because program transmissions are, for the most part, private line toll services information concerning traffic is not generally available.

We turn, therefore, to a report prepared for the President's Task Force on Communications Policy--the Spindletop Report, "Future Opportunities for Television."[18] In this report, data were compiled that indicate that, on the average, each of the three major networks in the United States broadcast 3,588 hours per year during the last several years.

The question of future television activity is, of course, of major interest to the country. As the cited report points out, greatly expanded cable facilities (CATV) should be encouraged; viewers need a wider range of programming, including public, community, and educational programs; and in general future opportunities for television depend to a large extent on making more channels available to accommodate this increased programming.

While it is distinctly not possible to predict what will happen in this very complex field--including CATV--it is apparent that the spirit of the recommendations and advice cited above will be heeded in the next twenty years; that is, that the number of channels available to the viewer

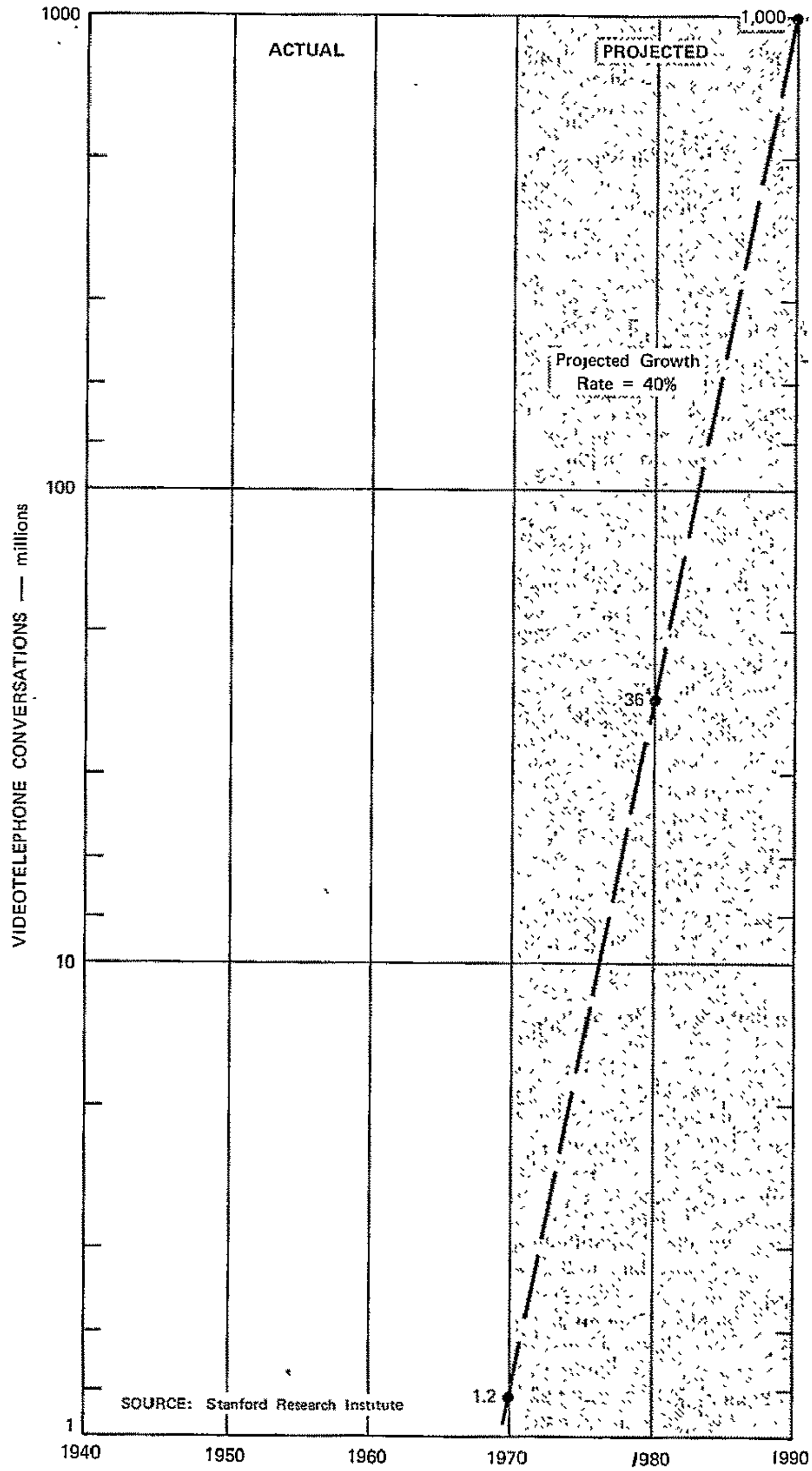

FIGURE 9 VIDEOTELEPHONE SERVICE

will be substantially increased. Of course, it is not a matter of government edict that this will take place, although it is well-known that government can either encourage or discourage such developments. Rather, in the United States it is generally a market force that determines the spread of innovation, new techniques, new products, and new services. In this connection, there are many indications that a greater variety of broadcast services will be provided in the future, both by cable and by other means, even including, perhaps, direct broadcast satellites.

On the other hand, there are no past indicators to provide quantitative guidance as to how these new developments may take place. Even the method of historical analogy and logistic curves is of little use in this situation. Therefore, we must fall back on the device of projecting several alternate future possibilities regarding the number of national networks in operation during the time period of interest, as shown in Figure 10.

We assume that sometime during the next one or two years the movement to tie together the present National Educational Television stations will be substantially accomplished, with the impetus provided by the Corporation for Public Broadcasting and the Public Broadcasting Act of 1967. This will result in four national networks in 1970. The alternate possibilities depicted for 1990 are five, ten, and twenty networks. We assume each of these networks will broadcast approximately the same number of hours per year as the present three (3,600 hours), resulting in the three forecasts of 180,000 hours, 360,000 hours, and 720,000 hours of broadcasting in 1990. Lacking any other guidance, we also assume straight line growth trends between 1970 and these three alternate estimates.

Telegraph

Since about 1945 telegraph traffic has been consistently declining, as shown earlier in Figure 5. It reached a peak in 1945, in fact, that was exactly equal to its value in 1929. Between these two years there were two valleys or troughs in the series, one in 1933--corresponding to the low point of the depression of the thirties--and one in 1938. After 1945 the series has never recovered. Between 1945 and 1955 there were minor fluctuations, but the decline has been exceptionally uniform since that time. These data are plotted in Figure 11 and projected to 1990. The projection is straightforward in this case, relying on the consistency of the series between 1945 and 1967.

It should be pointed out that the four years, 1964 to 1967, show a slight improvement in the overall trend. This may very well be indicative

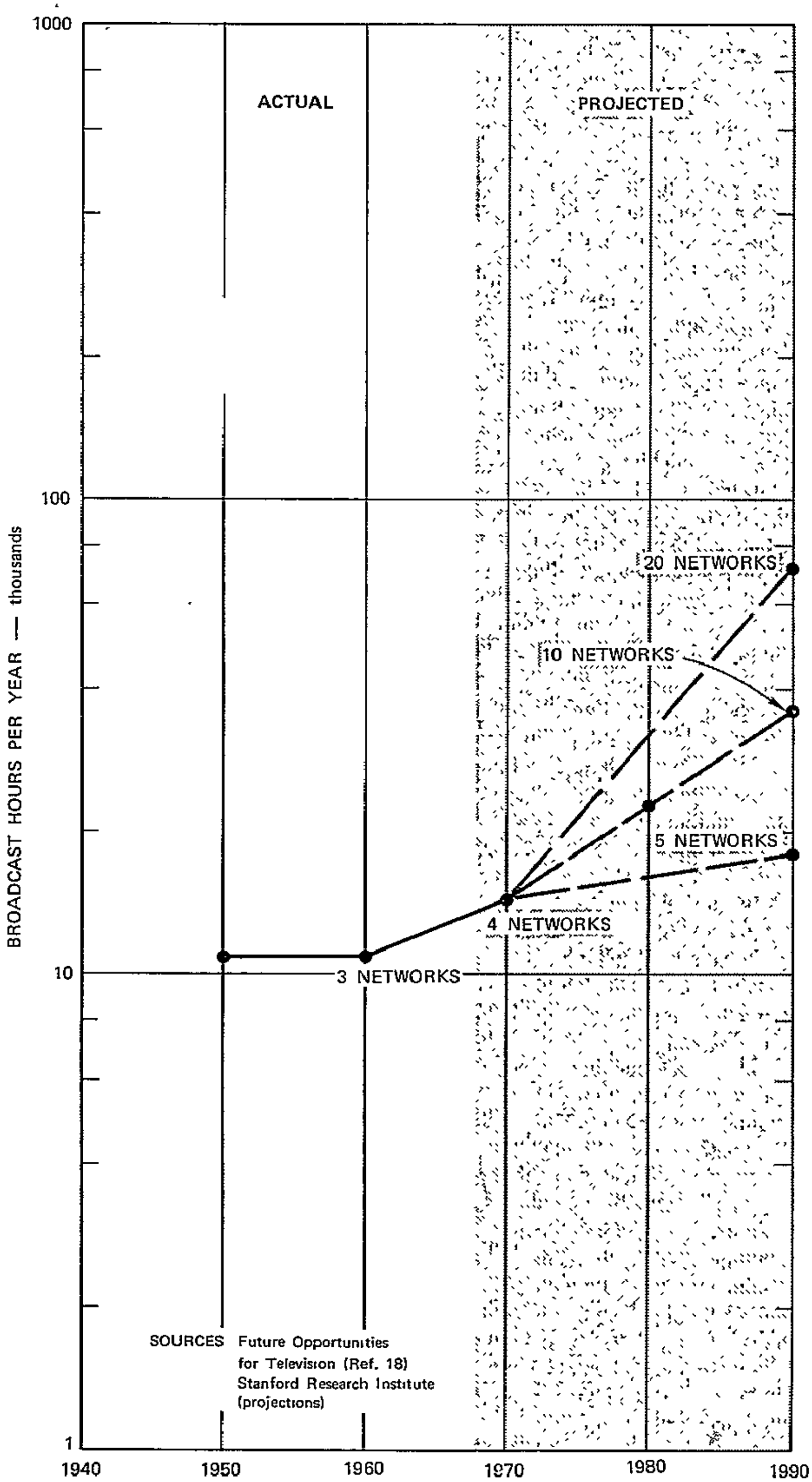

FIGURE 10 NETWORK TELEVISION TRANSMISSION

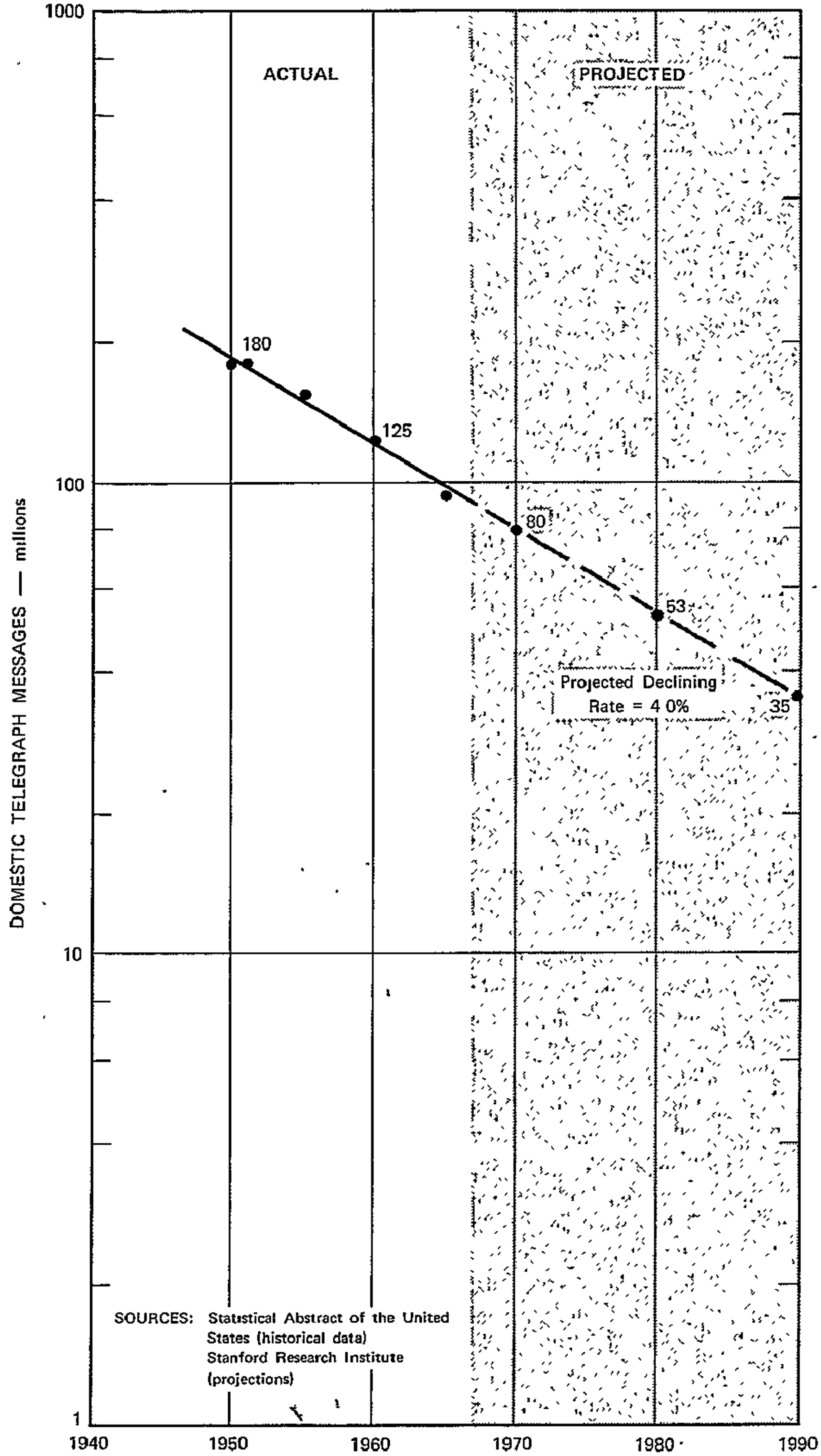

FIGURE 11 TELEGRAPH SERVICE

of a slower decline in future years, and possibly even a reversal of the trend, as a result of the telegraph carrier's more vigorous management in recent years. However, it is not appropriate to project such a reversal from the data available, but it is entirely reasonable that it could occur, substantially modifying the projection given.

Stolen Vehicles and Stolen Personal Property Information Transfer

In the next two series, and in several of those to follow, indicators of information transfer are projected rather than actual transactions. As explained earlier, we assume that these variables bear a predictable, usually linear relationship to the number of transactions required for the service. These relationships are computed in the section entitled "Conversion to Bits per Year."

From the Statistical Abstract of the United States[12] we extract the series on Crimes and Crime Rates by Type. This series is given in seven categories, representing the basis of the FBI's Crime Index. From these data, auto theft is plotted in Figure 12 as representative of information transfer potentially required for tracing and recovering stolen vehicles. These data are also quite uniform when plotted on semilog paper, indicating an effectively constant growth rate since 1950. This is used as a base for projecting to 1990, as shown on the chart.

Similarly, Figure 13 shows burglary cases as an indicator of stolen personal property information transfer. In this case, a projection of crimes per 100,000 population is plotted as well as number of crimes. If the crime rate is projected as a straight line from past data (curve A), this results in an even greater rate of change in number of cases, as shown by the topmost portion of curve B--1,800, 4,200, and 110,000 cases. Alternatively, the series "number of cases" itself may be projected as a straight line, as shown in the lower portion of curve B--1,700, 3,500, and 7,000 cases. Although we do not know which of these methods is more likely to be correct, it appears that, in agreement with Figure 12, the more conservative projection using number of cases directly is suitable for our purposes.

Motor Vehicle Registrations

The series "motor vehicle registrations" is indicative of the information transfer required for registration renewal each year. Figure 14 illustrates this series, projected to 1990 at an annual growth rate of 4.1 percent based on the years 1950 to 1967. The resulting figures are:

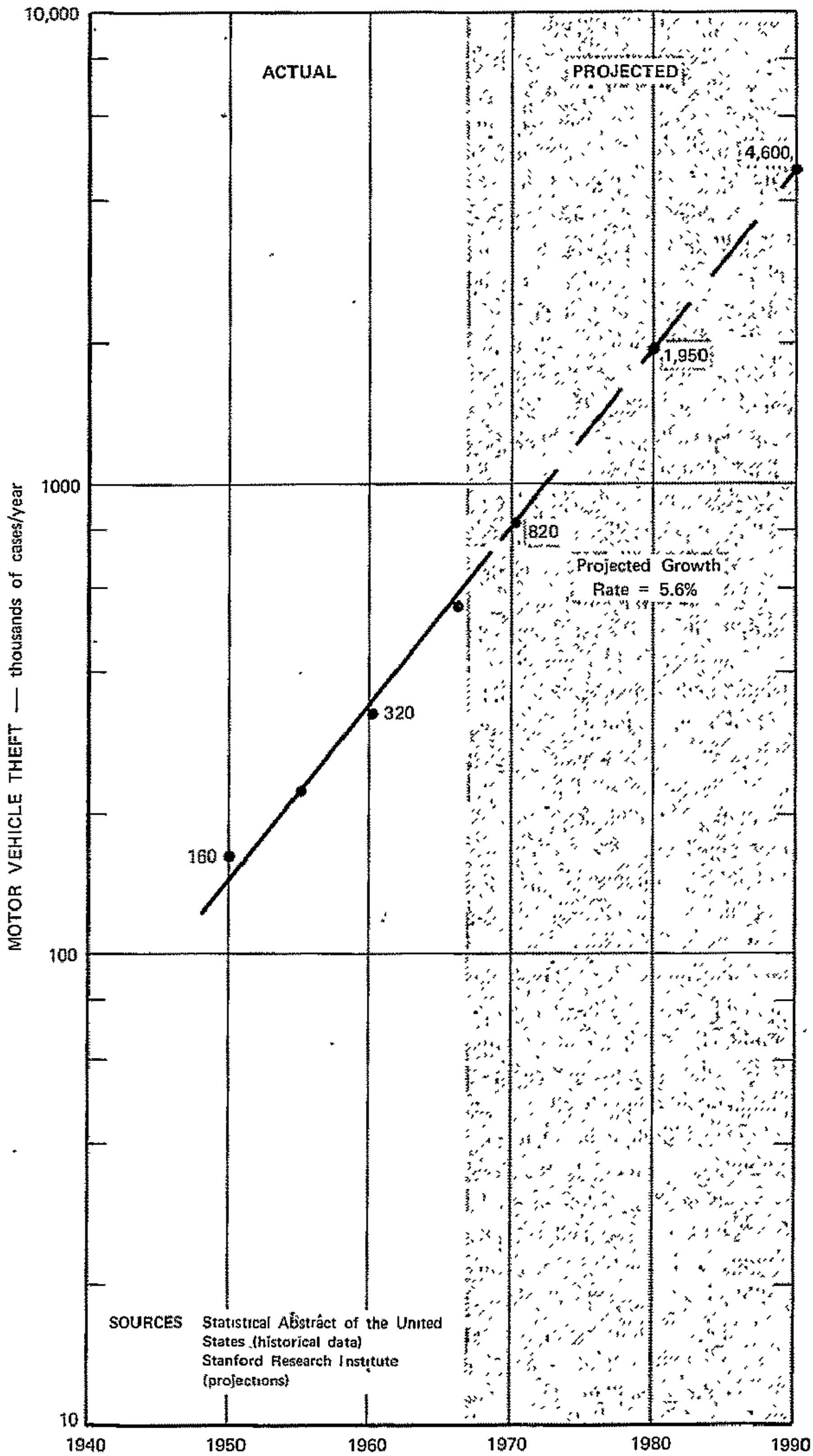

FIGURE 12 STOLEN VEHICLE INFORMATION TREND INDICATOR

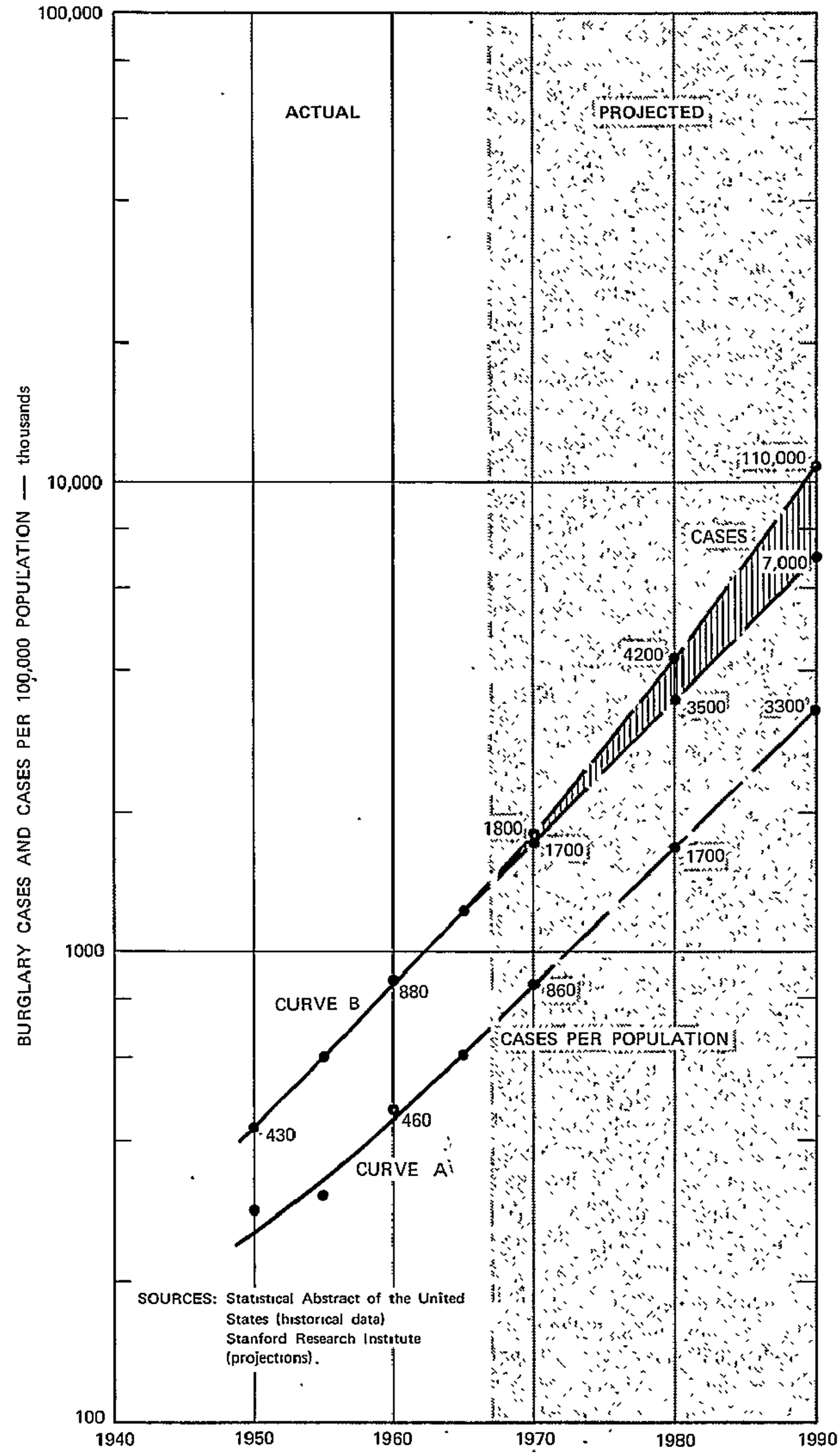

FIGURE 13 STOLEN PROPERTY INFORMATION TREND INDICATOR

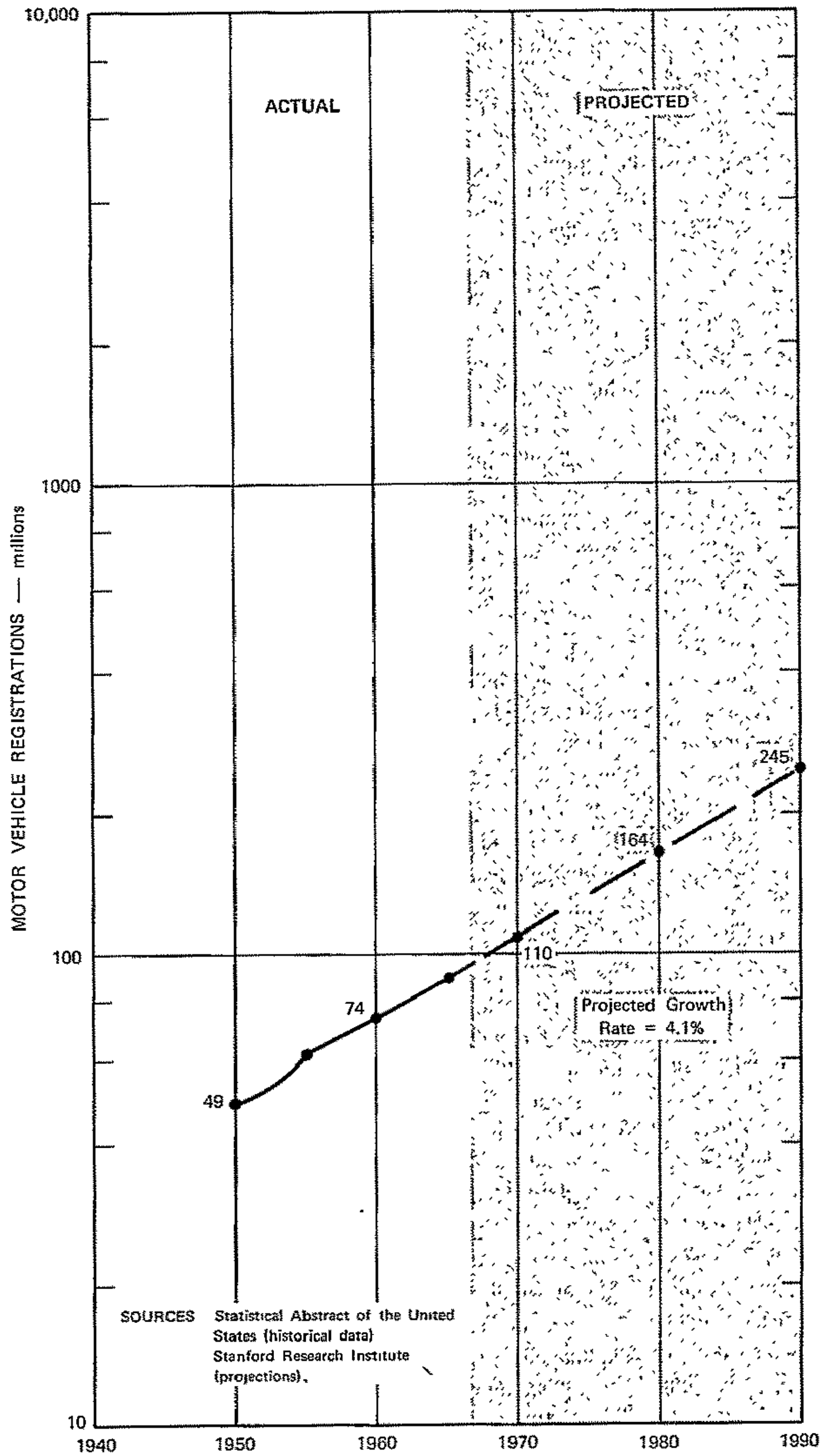

FIGURE 14 MOTOR VEHICLE REGISTRATION RENEWAL TREND INDICATOR

110 million, 164 million, and 245 million for 1970, 1980, and 1990, respectively.

Patent Searches

A trend indicator for number of searches of patent files is difficult to establish. Series on patent applications and patents issued are available, and these are illustrated in the lower part of Figure 15 for comparison.

Because these measures are representative of the size of the store (or file) rather than number of transactions or accesses to it, another measure is necessary. "Prints furnished," a statistic given in Annual Reports of the Commissioner of Patents[19] serves this purpose. This number, approximately 25,000 per day, has had an irregular history. Between 1962 and 1966 it increased markedly; since then, in 1967 and 1968 the series decreased.

None of these data provide an adequate basis for projection of a trend. We have, therefore, assumed a relatively fixed level of requests at 6.6 to 7.0 million per year. A qualitative justification for not assuming a decrease might be based on the fact that, as the patent files become easier to search--as a result both of the computerization of the files and of the gradual transition to real time access that we implicitly assume in this study--more demand for searches, and for copies of patents, will be generated. It is clear that this rationalization cannot yet be supported, however.

Value Transfer--Checks and Credit Transactions

The checkless society has been much discussed in the literature, as well as being the subject of several conferences and a number of studies during the past several years.

To establish potential demand for such services, we turn to data on the number of transactions involving checks and credit purchases over the last several years, as shown in Figure 16.

These data indicate that the number of checks written in the United States--about 70 million each working day at the present time--is growing at a rate of approximately 6 percent per year. Credit transactions are growing considerably faster--about 12 percent per year. In magnitude, credit transactions are only slightly greater than checks at the present

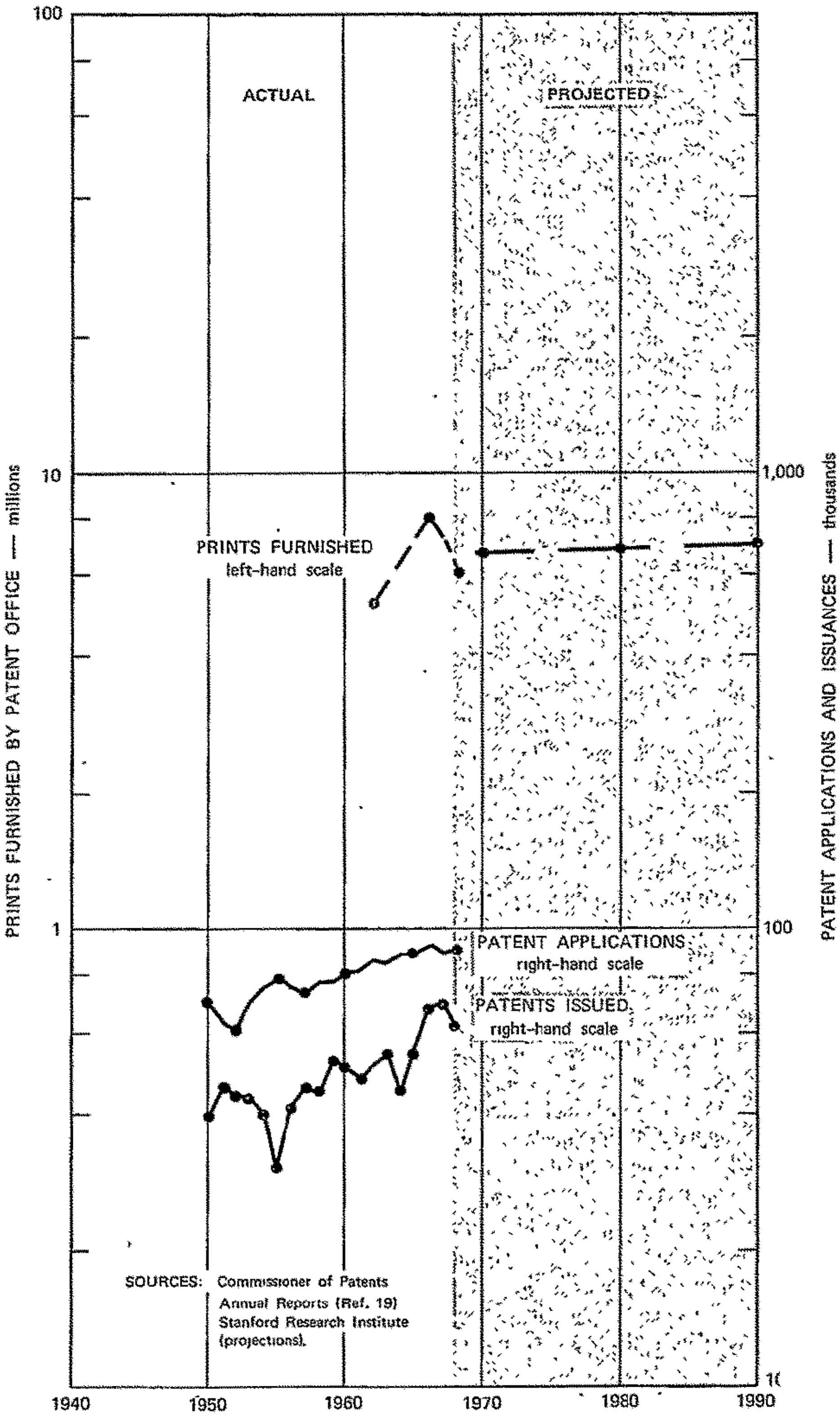

FIGURE 15 PATENT SEARCHES TREND INDICATOR

time (33 billion versus 23 billion per year). Before 1980, however, if present growth rates continue credit transactions will be more than double the number of checks, and in 1990 some four times as great (270 billion versus 70 billion).

All of these transactions are directly replaceable with some form of electronic funds transfer system.[20] As before, we do not attempt to project the transition to such a system, but rather make note only of the potential number of items involved. Summing both checks and credit transactions, the figures are: 56 billion, 135 billion, and 340 billion transactions per year for 1970, 1980, and 1990, respectively.

Stock Transfers

Data indicative of information required for stock market transactions are readily available. Average daily trading volume, for example, has been steadily increasing since 1940, as shown in Figure 17. Because the market is volatile, the series fluctuates more than many others. The overall trend is clearly upward however; an increase is projected here of 7.2 percent per year, using 1945 for a base year.

While the number of shares traded provides an indication of growth, it is clear that this number does not equal the number of transactions. To find the latter we need an indication of the average number of shares traded per transaction. This information was developed by sampling several day's transaction volumes on the New York Stock Exchange, then dividing by trading volumes on those same days. In round numbers this ratio averages about 28 percent. Thus, transactions per year are projected to be 1.2 billion, 2.5 billion, and 4.9 billion (lower curve, Figure 17).

It should be borne in mind that the mission or service projected here concerns stock transfers, not quotations. Thus, it is a "value transfer" mission, as opposed to a data inquiry and retrieval application. According to the best information available, total transactions for on-line real time stock quotation services (such as Bunker Ramo's Telequote service) also amount to approximately one billion per year.

Airline Reservations

Information transfer for airline reservations correlates, quite naturally, with number of airline passengers (for example, see Ref. 21). This series, given in Figure 18, has also been regularly increasing,

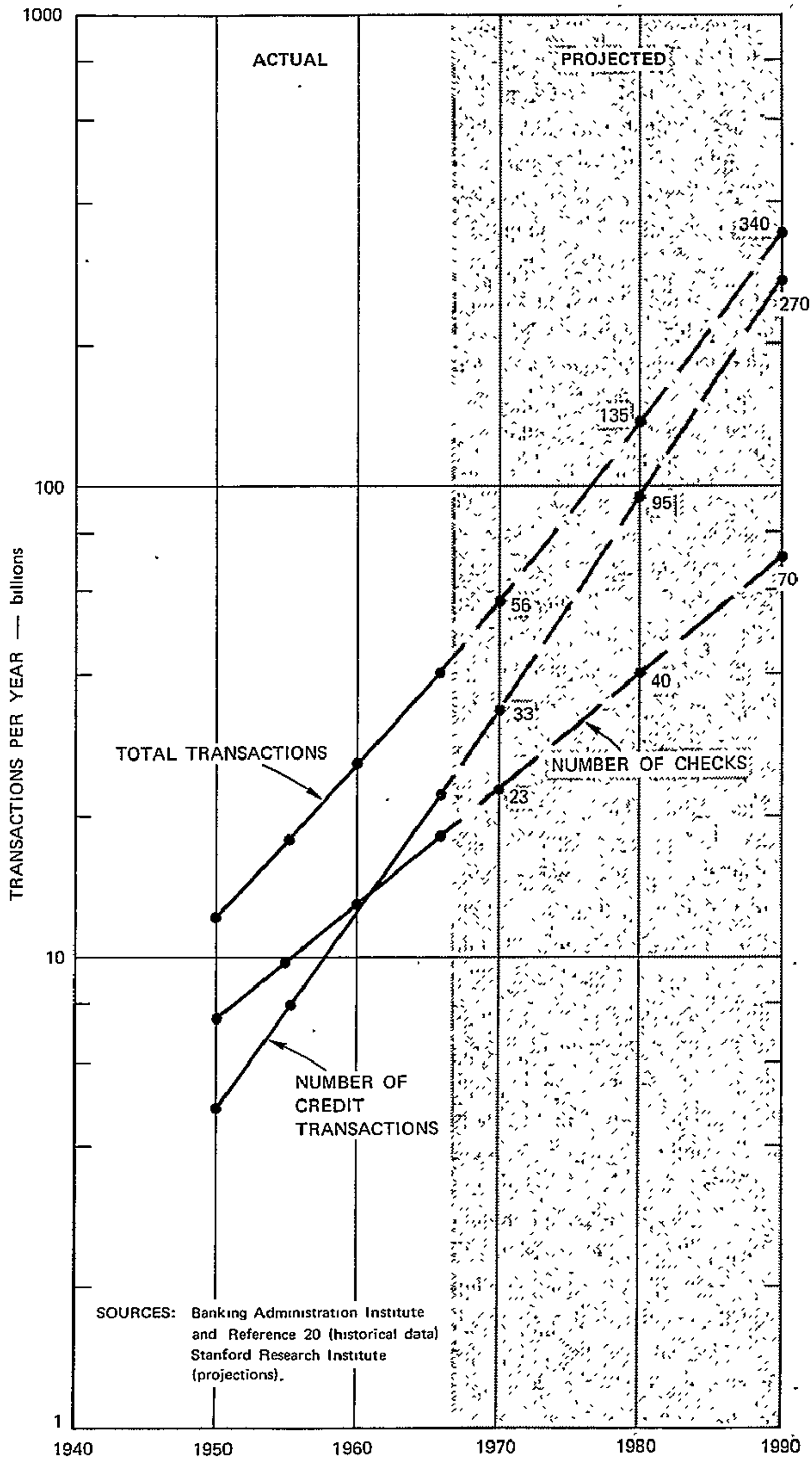

FIGURE 16 CHECK AND CREDIT TRANSACTIONS

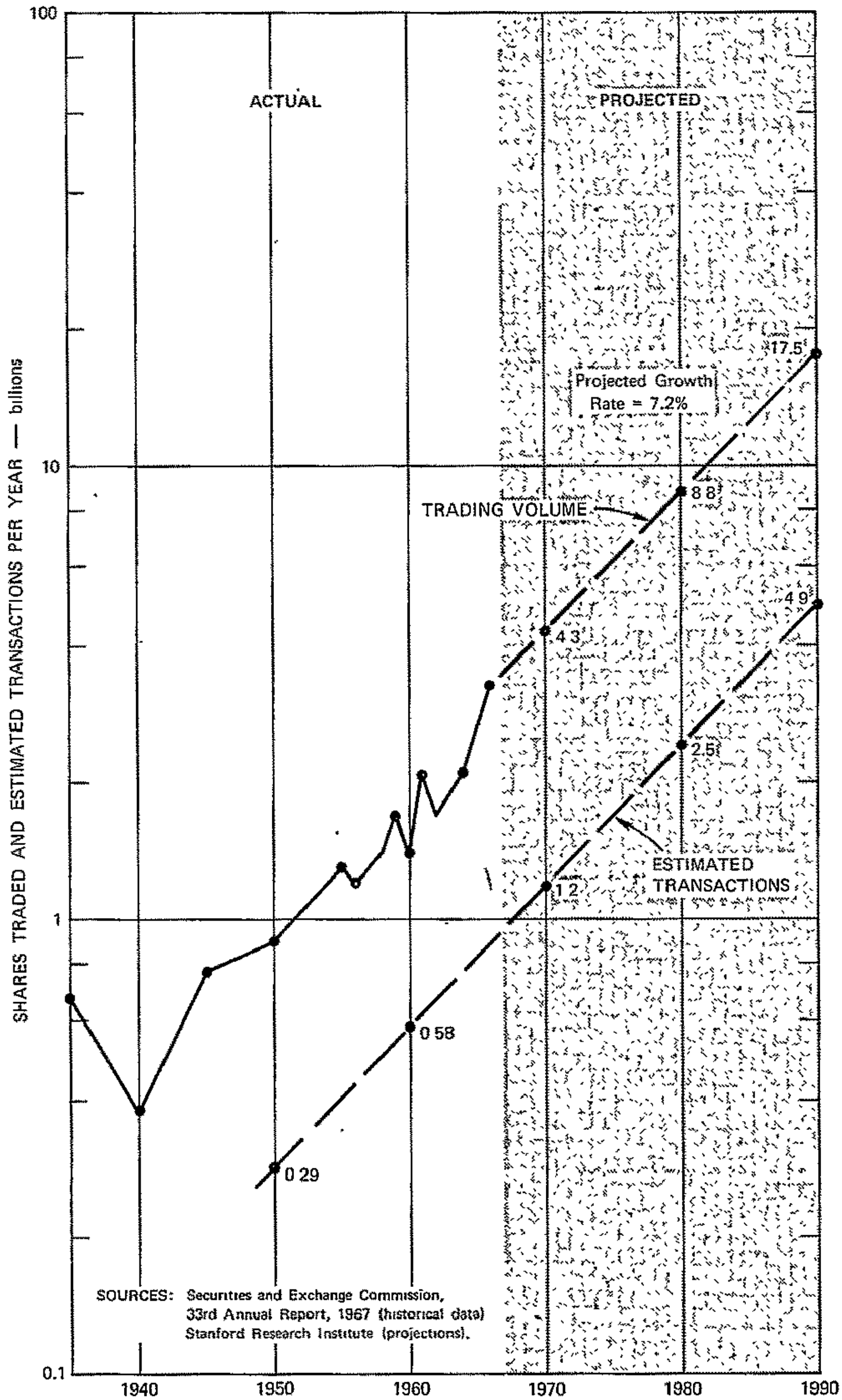

FIGURE 17 STOCK TRANSFER INFORMATION TREND INDICATORS

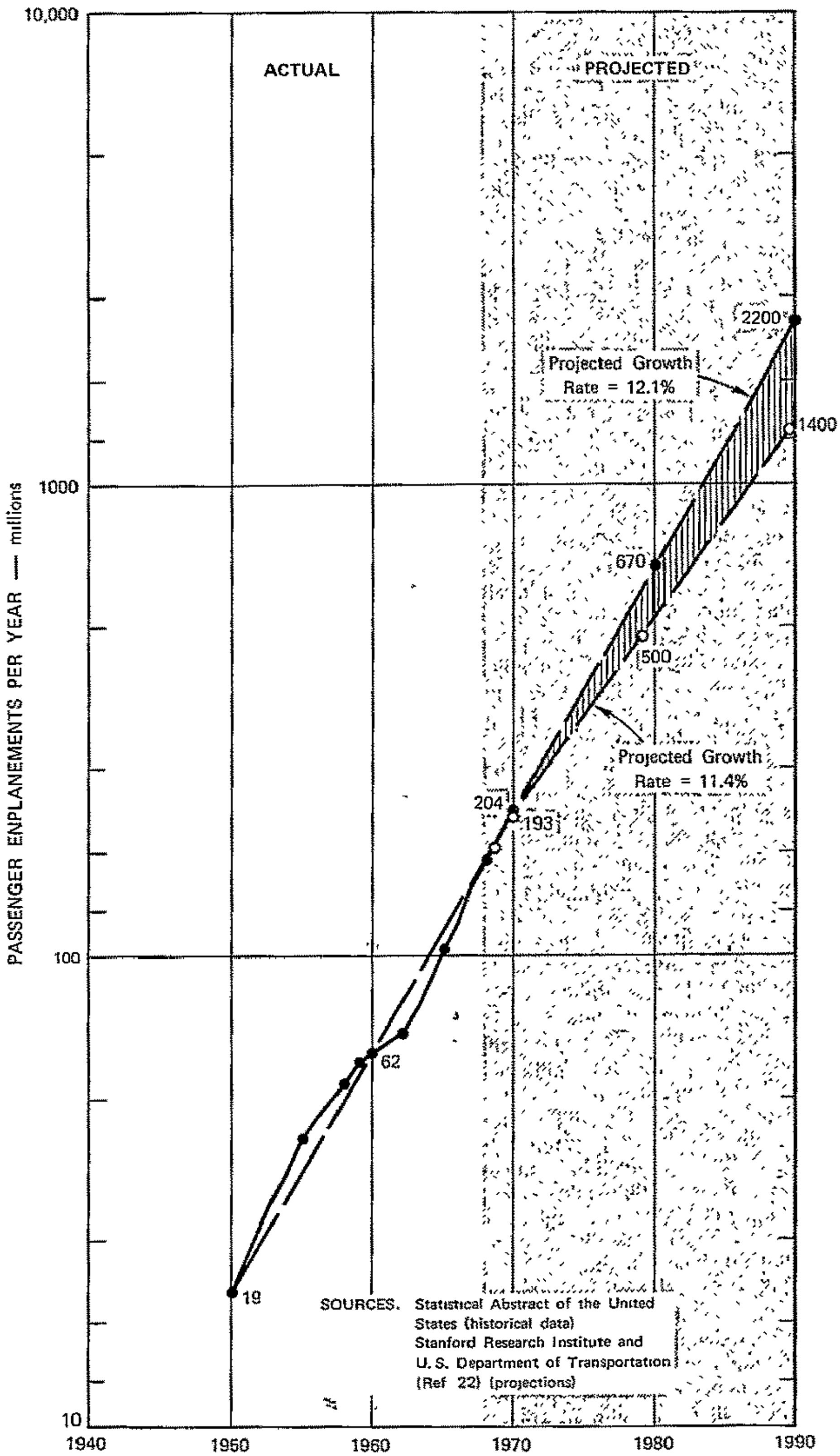

FIGURE 18 AIRLINE RESERVATION INFORMATION TREND INDICATOR

although with minor fluctuations. The data come principally from the Statistical Abstract[12] and from Aviation Forecasts, Fiscal Years 1969-1980.[22] As indicated in Figure 18, a projection of an annual 12.1 percent growth may be derived, using a straight line projection based on the rate of growth between 1950 and 1967. In contrast, the Office of Policy Development of the FAA projects the more conservative rate of 11.4 percent growth.

Although we prefer to "err on the high side" in these projections, it is reasonable to conclude that the growth rate in this series may be declining over the long term, despite its increase between 1962 and 1968. For example, again using data from the Statistical Abstract, the annual growth rate in the two five year periods 1940-1945 and 1945-1950 was 21 percent whereas since that time it has been 17 percent or less. Therefore, we choose the more conservative trend, 17 percent, leading to the projection of 193 million, 500 million, and 1.4 billion in 1970, 1980, and 1990, respectively.

First Class and Airmail

The last two projections illustrated concern what we have referred to as "written material." The first of these is first class and airmail. An increase in this series is projected at 3.5 percent per year, using again, as shown on Figure 19, data from the Statistical Abstract.

A more detailed projection of mail volume was recently prepared by Arthur D. Little, Inc., for the President's Commission on Postal Organization.[23] This forecast takes into consideration some of the potential substitution effects deriving from the use of electronic funds-transfer methods instead of checks, thus "curbing the exponential rise of mail volume and producing a nearly linear plot of volume versus time." (See Appendix B.) However, over the two decades 1970 to 1990 this effect will be minor. Furthermore, to be consistent with the other projections, we wish to ignore such substitution at present, thereby accepting the exponential projection shown in the figure. This results in a first class and airmail volume of 50 billion, 70 billion, and 100 billion pieces over the twenty-year period of interest.

Remote Printing of New Books

Many examples of possible technological developments concerning the publishing industry were found in the literature. We have attempted to identify a number of these in the reference list and bibliography. For

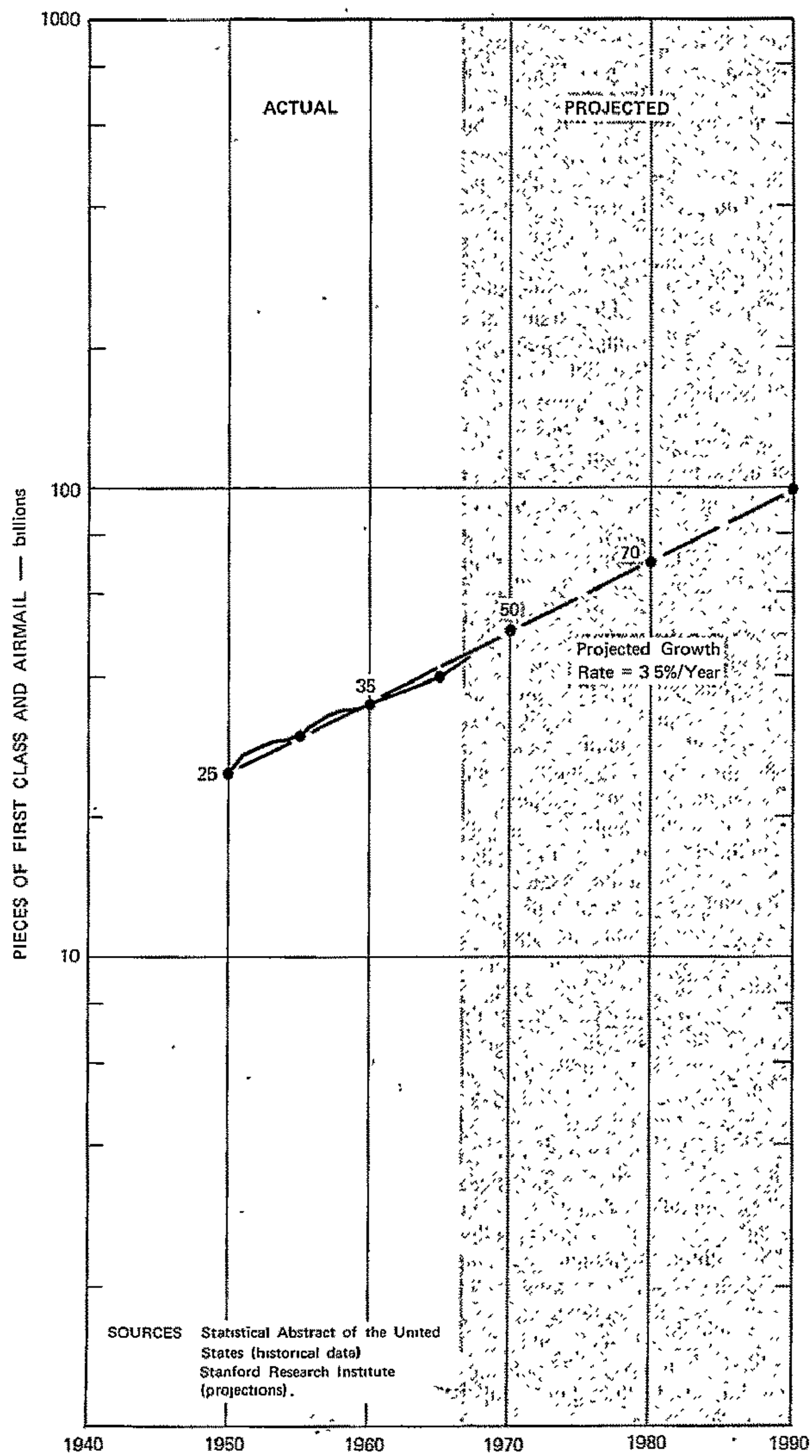

FIGURE 19 FIRST CLASS AND AIRMAIL VOLUME

example, in Growth Pace Setters in American Industry, 1958-1968[16] is the statement, "The printed format will not disappear, but the way in which it is produced and distributed may alter radically

One of these techniques is remote printing of new books, the example illustrated here. The concept envisioned is similar to broadcast transmission; copies of the text of new books are distributed to remote printing plants in other parts of the country. Although one might envision a situation in which a copy of all books is kept in electronically accessible form at a central repository, there to be called upon for remote printing each time a "sale" is made,[24] the concept illustrated here is more modest, and perhaps even somewhat more realistic. That is, it assumes transfer of the contents only once for each new title, as radio and television programs are distributed, with recording and printing of the contents at the destination.

For this mission or service the number of new titles is the appropriate statistic. This series is shown in Figure 20. As indicated there, it has fluctuated widely since 1950, being sometimes up and sometimes down, but showing clearly the often referred to trend of the "information explosion"--doubling every 10 to 15 years. Between 1950 and 1968 the series increased from 11,022 to 30,387, resulting in an annual growth rate of 5.8 percent over the period. We continue this trend in the projection to 1990, resulting in the following figures: 1970, 34,000 titles; 1980, 60,000 titles; 1990, 105,000 titles.

Summary of the Projections

Table 7 summarizes the projections shown on the previous figures, and includes estimates for a number of remaining services that were also investigated. In total, 28 services were analyzed, including voice service (telephone), 2 video services (video telephone and network broadcast transmission), 22 record and data services (telegraph plus 21 data transmission applications), and 3 written services (mail, books, and newspapers) For each of these a projection parameter unique to that service was established. This is given in the column "Units." The values of the projection variable are then given for the years 1950 and 1960 where historical data are available, and for 1970 to 1990 in all cases.

Conversion to Bits per Year

In this section we give the rationale and conversion factors used to derive information transfer volume in bits per year resulting from the

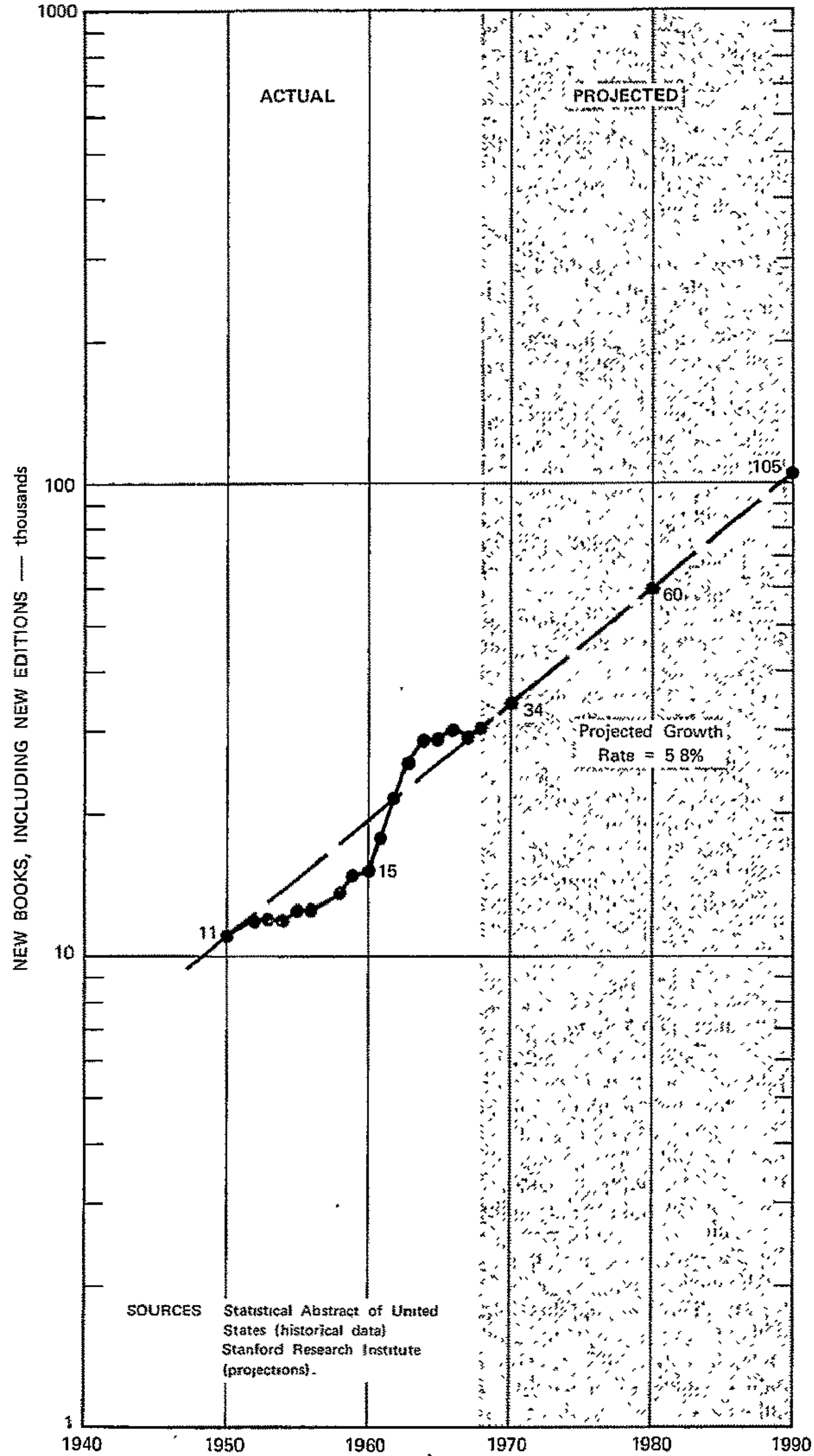

FIGURE 20 NEW BOOKS

Table 7

SUMMARY OF DEMAND TREND PROJECTIONS

Service	Units	1950	1960	1970	1980	1990
Voice						
Telephone	calls/year X 10^9	62	105	174	286	482
Video						
Video telephone	calls/year X 10^6	0	0	1	36	1,000
Television transmission	hours/year X 10^3	11	11	14	32*	72*
Record and Data						
Telegraph	messages/year X 10^6	180	125	80	53	35
Stolen vehicle information transfer	cases/year X 10^3	160	320	820	1,950	4,600
Stolen property information transfer	cases/year X 10^3	430	880	1,700	3,500	7,000
Facsimile transmission of "mug shots," fingerprints, and court records	cases/year X 10^6	2	3.5	7	13	25
Motor vehicle registration	items/year X 10^6	49	74	110	164	245
Driver's license renewal	items/year X 10^6	38	48	60	75	90
Remote library browsing	accesses/year X 10^6	0	0	neg.	5	20
Remote title and abstract searches	searches/year X 10^6	0	0	neg.	8	20
Interlibrary loans	books/year X 10^6	--	--	neg.	40	100
Remote medical diagnosis	cases/year X 10^6	0	0	20	60	200
Remote medical browing	accesses/year X 10^6	0	0	20	60	200
Electrocardiogram analysis	cases/year X 10^6	0	neg.	20	60	200
Patent searches	searches/year X 10^6	6	6	6.5	7	7
Checks and credit transactions	transactions/year X 10^9	11	25	56	135	340
Stock exchange quotations	transactions/year X 10^9	0	0	1	2	4
Stock transfers	transactions/year X 10^6	290	580	1,200	2,500	4,900
Airline reservations	passengers/year X 10^6	19	62	193	500	1,400
Auto rental reservations	reservations/year X 10^6	0	neg.	10	20	40
Hotel/motel reservations	reservations/year X 10^6	--	--	25	50	100
Entertainment reservations	reservations/year X 10^6	--	--	100	140	200
National Crime Information Center	transactions/year X 10^6	0	0	6	20	70
National legal information center	transactions/year X 10^6	0	0	neg.	5	30
Written						
Mail (first class and airmail)	letters/year X 10^9	25	35	50	70	100
Books (remote printing)	new titles/year X 10^3	11	15	34	60	105
Newspapers (facsimile transmission)	number of newspapers using service	0	1	2	10	20

* Assumes the projection to 20 networks in 1990.

projected transactions given above. Table 8 summarizes the information. In the case of the telephone there is some controversy with regard to the assumption of 64,000 bits per second to code analog voice signals into digital. This figure was derived originally from Pierce.[5] It represents the current method of coding voice using pulse coded modulation (PCM), as exemplified by the T-1 digital carrier systems now in use in the telephone plant, and by the T-2 and T-5 systems currently under development.

Because those are accepted systems, the controversy arises not so much from the assumption of 64 kilobits per second per se, as from the implication that all voice calls might be digital at some time in the future. This is clearly not the case. From all indications, the most likely transition to digital transmission in the next twenty years will be in the carrier plant, that is, between toll, tandem and central offices, but not in the local loop.* Thus, at least those calls confined to a single central office will remain in analog form, as well, probably, as some proportion of those between central offices. At this point it is not clear, however, that another conversion factor would be more appropriate for those calls. Thus, for purposes of consistency we use the 64 kilobit figure.

In videotelephone service the problem is similar, in that calls traversing less than about six miles will remain analog, whereas those traveling longer distances will be digitized, if the AT&T system is used.[14] The difficulty derives from attempting to enumerate the calls by distance. Therefore, for simplicity we assume the conversion rate now being used in practice, 6.3 million bits per second. The conversion rate for television is also derived from Pierce.[5] For development of bits per year in 1990, twenty networks are assumed. In the case of pages of text that are accessed, searched and/or transmitted, conventions are established as follows:

1. Alpha coded text--that is, coding of each character into bits--requires on the average about 30,000 bits per page. This convention assumes approximately 70 characters per line, 50 lines per page, and 8 bits per character.

* This information was derived principally from discussions with E. B. Shapiro of SRI and members of the technical staff at Bell Telephone Laboratories. A discussion of the carrier plant including toll, tandem and central offices is given in Ref. 5.

Table 8

DEVELOPMENT OF BITS PER YEAR*

Telephone

$(482 \times 10^9$ calls/year$) \times (6$ min/call$)$
$\times (60$ seconds/minute$) \times (64{,}000$ bits/second$)$
$= 1.1 \times 10^{19}$ bits/year

Videotelephone

$(1.0 \times 10^9$ calls/year$) \times (6$ min/call$)$
$\times (60$ seconds/minute$) \times (6.3 \times 10^6$ bits/second$)$
$= 2.3 \times 10^{18}$ bits/year

Television Transmission

$(72 \times 10^3$ hours/year $\times (3600$ seconds/hour$)$
$\times (64 \times 10^6$ bits/second$)$
$= 1.7 \times 10^{16}$ bits/year

Telegraph

$(35 \times 10^6$ messages/year$) \times (20$ words/message$)$
$\times (50$ bits/word$)$
$= 3.5 \times 10^{10}$ bits/year

Stolen Vehicle Information Transfer

$(4.6 \times 10^6$ cases/year$) \times (3000$ bits/case$)$
$= 1.4 \times 10^{10}$ bits/year

Stolen Property Information Transfer

$(7.0 \times 10^6$ cases/year$) \times (3000$ bits/case$)$
$= 2.1 \times 10^{10}$ bits/year

Facsimile Transmission of "Mug Shots," etc.

$(25 \times 10^6$ cases/year$) \times (10$ pages/case$)$
$\times (3 \times 10^6$ bits/page$)$
$= 7.5 \times 10^{14}$ bits/year

Motor Vehicle Registrations

$(245 \times 10^6$ items/year$) \times (6000$ bits/item$)$
$= 1.5 \times 10^{12}$ bits/year

Drivers' License Renewal

$(90 \times 10^6$ items/year$) \times (6000$ bits/item$)$
$= 5.4 \times 10^{11}$ bits/year

Remote Library Browsing

$(20 \times 10^6$ accesses/year$) \times (200$ pages/access$)$
$\times (3 \times 10^5$ bits/page$)$
$= 1.2 \times 10^{15}$ bits/year

Table 8 (Continued)

Remote Title and Abstract Searches

$(20 \times 10^6$ searches/year$) \times (30$ pages/search$)$
$\times (3 \times 10^4$ bits/page$)$
$= 1.8 \times 10^{13}$ bits/year

Interlibrary Loans

$(100 \times 10^6$ books/year$) \times (10^7$ bits/book$)$
$= 1.0 \times 10^{15}$ bits/year

Remote Medical Diagnosis

$(200 \times 10^6$ cases/year$) \times (30{,}000$ bits/case$)$
$= 6 \times 10^{12}$ bits/year

Remote Medical Literature Searches

$(200 \times 10^6$ searches/year$) \times (30$ pages/search$)$
$\times (3 \times 10^4$ bits/page$)$
$= 1.8 \times 10^{14}$ bits/year

Electrocardiagram Analysis

$(200 \times 10^6$ tests/year$) \times (30{,}000$ bits/test$)$
$= 6.0 \times 10^{12}$ bits/year

Patent Searches

$(7 \times 10^6$ searches/year$) \times (6$ pages/search$)$
$\times (3 \times 10^6$ bits/page$)$
$= 1.3 \times 10^{14}$ bits/year

Checks and Credit Transactions

$(340 \times 10^9$ transactions/year$) \times (50$ characters/transactio
$\times (8$ bits/character$)$
$= 1.4 \times 10^{14}$ bits/year

Stock Exchange Quotations

$(4 \times 10^9$ transactions/year$) \times (100$ bits/transaction$)$
$= 4 \times 10^{11}$ bits/year

Stock Transfers

$(4.9 \times 10^9$ transactions/year$) \times (3000$ bits/transaction$)$
$= 1.5 \times 10^{13}$ bits/year

Airline Reservations

$(1.4 \times 10^9$ passengers/year$) \times (3$ transactions/passenger$)$
$\times (200$ characters/transaction$) \times (8$ bits/character$)$
$= 6.7 \times 10^{12}$ bits/year

Table 8 (Concluded)

Auto Rental Reservations

$(40 \times 10^6$ reservations/year) $\times$ (1000 bits/reservation)

$= 4 \times 10^{10}$ bits/year

Hotel/Motel Reservations

$(100 \times 10^6$ reservations/year) $\times$ (1000 bits/reservation)

$= 1 \times 10^{11}$ bits/year

Sports and Cultural Event Ticketing

$(200 \times 10^6$ transactions/year) $\times$ (200 bits/transaction)

$= 4 \times 10^{10}$ bits/year

National Crime Information Center

$(70 \times 10^6$ transactions/year) $\times$ $(3 \times 10^5$ bits/transaction)

$= 2.1 \times 10^{13}$ bits/year

National Legal Information Center

$(30 \times 10^6$ searches/year) $\times$ (10 pages/search)

$\times$ $(3 \times 10^4$ bits/page)

$= 9.0 \times 10^{12}$ bits/year

First Class and Airmail

$(100 \times 10^9$ letters/year) $\times$ $(3 \times 10^5$ bits/letter)

$= 3.0 \times 10^{16}$ bits/year

Remote Printing of New Books

$(105 \times 10^3$ books/year) $\times$ $(10^7$ bits/book)

$= 1.1 \times 10^{12}$ bits/year

Facsimile Transmission of Newspapers

(20 newspapers using service) $\times$ (365 days/year)

$\times$ (50 pages/day) $\times$ $(180 \times 10^6$ bits/page)

$= 6.6 \times 10^{13}$ bits/year

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* Based on values projected for 1990 from Table 7.

2. No-gray-scale facsimile--similar to the quality of conventional copying machines--requires about 300,000 bits per page, based on the assumption of a 700 X 500 dot matrix.

3. High quality facsimile having sufficient resolution for half-tone photographs, and so forth, requires about 10 times the number of bits for no-gray-scale facsimile, or approximately 3 million bits per page.

For the most part, assumptions of average message lengths for telegraph and data transmission services are based on SRI estimates, although in some cases other data are available to further support these assumptions. For example, average patent length is given in Scientific Information Notes.[25] The characters of information required for check and credit transactions are given in reference 20. Airline transactions per passenger and average reservation message length are given in reference 21. Licklider[26] uses the figure of 10^7 bits per book. For newspaper facsimile, a rate of 55 pages per newspaper per day is given in Forbes Magazine.[27] The data rate for high quality newspaper facsimile (180 megabits per page) was established in discussions with staff members of the Bell Telephone Laboratories and the Wall Street Journal.

Local Versus Long Distance Transmission

Throughout this study it was recognized that a separation of demand trends by distance was relevant and applicable to the study. What SRI determined, however, was that except in special cases such as telephone and a few others, there is little or no data available to support estimates of potential traffic separation by distance. For example, for digital data transmission at the present time such information is not known even by the telephone companies. In this area, therefore, a more detailed investigation, perhaps using sampling or survey methods, should be performed in order to gain insight into such traffic patterns.

Despite these difficulties, in order to further classify the gross, total message traffic projections made in the previous section, rough estimates (assumptions) of local versus nonlocal traffic may be made. Such a list is given in Table 9. For three of the services in this table--telephones, checks and credit transactions, and mail--data were collected during the study to support the estimates given. For the others, however, no supporting evidence can be cited. Thus, they should be interpreted with caution, as indicated on the table.

Table 9

ESTIMATES OF LOCAL VERSUS LONG DISTANCE TRAFFIC IN 1990
(percent)

Type of Service	Potential Traffic Demand: Local	Potential Traffic Demand: Long Distance
Voice		
Telephone	90%	10%
Video		
Video telephone	90	10
Television transmission	5	95
Record and Data		
Telegraph	10	90
Stolen vehicle information transfer	90	10
Stolen property information transfer	90	10
Facsimile transmission of mug shots, fingerprints, and court records	50	50
Motor vehicle registration	10	90
Driver's license renewal	10	90
Remote library browsing	90	10
Title and abstract searches	50	50
Interlibrary loans	90	10
Remote medical diagnosis	10	90
Remote medical browsing	10	90
Electrocardiogram analysis	60	40
Patent searches	0	100
Checks and credit transactions	60	40
Stock exchange quotations	0	100
Stock transfers	0	100
Airline reservations	0	100
Auto rental reservations	0	100
Hotel/motel reservations	0	100
Entertainment reservations		
National Crime Information Center	0	100
National legal information center	0	100
Written		
Mail (first class and airmail)	30	70
Books (remote printing)	0	100
Newspapers (facsimile transmission)	0	100

Note: With few exceptions, there is little or no published data to support these figures. Thus, in truth, they are assumptions, or guesses, rather than estimates, and should be so interpreted.

For telephone service, the required information is readily available, as shown earlier. Because separate statistical series have been recorded for many years, separate projections of local and long distance traffic may be made. Thus, in Table 9, long distance calls are projected to be 10 percent of total calls in 1990, because they are growing at a considerably faster rate than local calls at the present time (see Figure 8).

In the other two situations, only a portion of the required information is available; that is, a percentage of "local" versus "nonlocal" has been established, but only for a single point in time. These two cases are check transactions and mail volume. The data come in the first case from records indicating the source and disposition of items handled by banks, as shown in the following tabulation:[28]

Area Classification	Percent of Transactions†
On-Us*	41
Local Banks	20
Within Federal District	27
Other Federal District	12

Rough assumptions may be made concerning the distances involved in these transactions, as follows:

Area Classification	Assumed Distance (miles)
On-Us	0
Local Banks	0-10
Within Federal District	10-100
Other Federal District	Over 100

"On-Us" refers to checks drawn on and addressed to a single bank.
Percent of Transactions is really "percent of funds transferred." Thus, the implicit assumption of a one-to-one correspondence between transaction items and dollars transferred is also made in the calculations. This is, no doubt, an unwarranted assumption. It is difficult to establish another one, however, that is less objectionable.

Combining the two tabulations, it may be concluded that approximately 60 percent of the check transfers are what may be termed "local" (i.e., 10 miles or less), and conversely, approximately 40 percent may be termed nonlocal. These are the percentages recorded in Table 9.

Data relating to the separation of mail volume by distance are given in a study of letter delays in the Post Office.[29] In this study, local mail was shown to comprise 32 percent of total first class and airmail, 33 percent was nonlocal but moved less than 100 miles, and 35 percent travelled distances greater than 100 miles. In Table 9, these numbers are rounded to 30 percent for local. 70 percent for long distance.

For all remaining services, best estimates of local versus long distance percentages are supplied.

V VALIDATION OF RESULTS

This study has approached the problem of estimating the demand for communications and information transfer in a different way than has been tried in the past. Unconventional assumptions were made, estimates were derived in many cases based on best judgment, and so on. For this reason it seemed reasonable to conclude that a search for some means to validate the results of the study might be useful.

In this chapter we present several pieces of information that tend to confirm, in our opinion, the results presented earlier. This information falls into two general categories:

1. Evidence derived from calculating amounts of information that might be input to the total communications or information system from the input devices--telephones, terminals, data sets, television networks, and so on.

2. Evidence derived from other independent projections of message traffic in specific areas.

Data Generated by the Input Devices

Part of the information required to determine "total inflow" has already been given, that is, messages originating from telephones. Information generated by video devices inputting to the system--consisting of networks and videotelephones--has also been accounted for. Undoubtedly, a great amount of video information is now, and will be in the future, generated by closed circuit television cameras used mainly for local, specialized purposes. The bulk of this will not be input to a "connected U.S. information system." Conversely, what does find its way into the system conceived here should be accounted for in the generous allowance of 20 full time networks.

Since messages originating from videotelephones were also estimated in the previous section, only two major categories of information transfer remain to be accounted for--record, data, and private wire; and "written." In the first of these, input generated by public message telegrams has been counted. On the other hand, no assurance has been given that we have considered all transactions from all data sets.* What was accomplished in the last chapter was to calculate bits generated by a few specific, selected services.

On the other hand, it may be shown that the number of bits calculated previously for data transmission (Figure 1 and Table 1) is likely to be accurate within a factor of 10 or so. Projections of the number of data sets have been made in many places, for example Ref. 21 (p. 63). There, it is forecast that 10 million data sets will be in use in 1980. A very large growth rate was assumed for this projection, because, according to the best information available, these devices are increasing now at the rate of 45 to 60 percent per year. If such a growth rate were to continue to 1990, about one billion sets would be in use, which is ten times as many telephones as there are in the United States. Since this is quite unreasonable (it amounts to about 3 data sets for each man, woman, and child), we arbitrarily set an upper limit of 100 million sets in 1990. (By comparison, it took 90 years to reach this number of telephones.)

With this number of data sets, we can calculate the maximum number of bits that could be generated, and input to the information system, as follows. Ref. 21 indicates (p. 93) that 99 percent of all sets will continue to be low speed or voice grade devices. The bulk of these units--at least 90 percent--will be strictly low speed (i.e., teletype speed) data sets. The latter operate at between 150 and 300 bits per second, while voice grade is usually designated as 1200 to 2400 bits per second.† Now, assume that all data sets are used 24 hours a day, 365 days a year, at their highest speeds. The number of bits generated in one year is 100×10^6 (sets) $\times$ 90% (low speed) $\times$ 300 (bits/second) $\times\ 10^7$ (seconds/year) + 100×10^6 (sets) $\times$ 10% (voice grade) $\times$ 2400 (bits/second) $\times\ 10^7$ (seconds/year) = 5.1×10^{17} bits per year.

We have purposely double counted and made some rash assumptions in this calculation in order to "err on the high side." In all but a few cases, the voice grade data sets enumerated above will be used, as they

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* Data sets are the devices that encode digital information into analog information so that it can be transmitted over present day telephone lines.

† This is not meant to be a strict definition, as higher speed modems (modulator/demodulator) are actively being developed and introduced. The speed range given does, however, correspond to the projections given elsewhere for number of data sets in future years.

are now, in conjunction with data concentrators. Thus, they will be transmitting the same messages as those originating from the low speed sets. In a few cases not counted, very high speed core-to-core transfers will occur also. These, however, will be minor in comparison with the number of transactions (and bits) calculated above.

As shown in the summary of the report, our estimate of total bits for record, data, and private wire transmission is 3.0×10^{16} bits per year in 1990. Since it is quite unreasonable to assume that data sets will be used 24 hours a day--average telephone usage is about 24 minutes per day--the two estimates of total bits per year for this category are well within an acceptable margin of error.

Other Estimates of Message Traffic

In addition to the above, evidence as to approximate bit rates per year can be derived from other sources. These concern, usually, discrete applications areas that are similar to the services discussed throughout this report. Assembled here are six of these discrete pieces of substantiating evidence. They concern (1) collection of data from in situ sensors via satellite, (2) collection of data by weather satellites, (3) collection of data from other spacecraft, (4) estimates of total business transactions, (5) typical large scale corporate administrative network, and (6) estimates of total corporate network traffic.

Space Data Collection Systems

The first three items above may be grouped together as representative of different types of space data collection systems. In a paper mentioned earlier (Ref. 3), estimates are given for message traffic originating from in situ sensors (sensors placed in the atmosphere and on the surface of the earth) as 6×10^6 bits every 6 hours. Assuming continuous operation, this volume amounts to 8.7×10^9 bits per year. Reference 30 indicates that weather satellites may be generating 10 billion bits of data each day in the 1980s, or 3×10^{12} bits per year. Collection of data from other spacecraft has also been estimated elsewhere as about 1.5×10^{12} bits per year at the present time. These data come from the entire array of unmanned space probes and satellites now active.

Business Transactions

Items four to six above fall into the general category of business and administrative transactions. Here counting is much more difficult, because of the diverse nature of the messages or transactions. From a private client source, however, estimates of business transactions were made available for this study. These are given in Table 10. We have not verified any of the numbers in this table; therefore they should be considered only as indicators of the orders of magnitude involved in such transactions. Assuming 2000 bits per transaction, total volume from these transactions is

$$2.9 \times 10^{11} \text{ transactions} \times 2000 \frac{\text{bits}}{\text{transaction}} = 5.8 \times 10^{14} \text{ bits/year.}$$

Item 5 above (typical corporate net) derives from information presented in Ref. 31. The example network is that planned for International Business Machines' Advanced Administrative System (AAS), circa 1980. According to Ref. 31 (p. A-4), the overall system is designed to handle 3000 messages per minute into White Plains, New York, and 6000 accesses per minute. Also, message length averages 6 to 8 characters. From these data, total volume may be calculated as follows:

$$6000 \frac{\text{messages}}{\text{minute}} \times 144 \frac{\text{minutes}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times 100 \frac{\text{bits}}{\text{message}}$$

$$= 2.6 \times 10^{11} \text{ bits per year.}$$

The last item above, total corporate network traffic, has been derived independently by L. Feldner.* The following are excerpts from his final report to SRI:

> Survey of Industrial Communication Trends. A brief survey was made of some large scale industrial data communication systems. The sources for this survey were trade literature, contacts with communication managers and material in my files. The survey concentrated on large scale industrial installations. Airline reservation, banking, and finance systems were not included.

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* As indicated in the Preface, Mr. Feldner acted as a consultant to SRI on this project.

Table 10

ESTIMATES OF BUSINESS TRANSACTIONS
(Sales Orders)

	Annual Volume (number of transactions)
Retail	
Food chain	8×10^9
Food independent	10×10^9
Gasoline	16×10^9
Drug	15×10^9
Other retail	10×10^9
Personal Services	
Restaurants	14×10^9
Laundry	5×10^9
Barber, beauty	1×10^9
Repair	1×10^9
Amusements	1×10^9
Communications	
Postal	7×10^{10}
Telephone, local	11×10^{10}
Telephone, long distance	5×10^9
Telephone, install	5×10^7
Telegrams	1×10^8
Material Industries	
Agents	1×10^8
Wholesalers	1×10^8
Stock manufacturers	10×10^8
Extractive	1×10^7
Construction	1×10^6
Custom manufacturers	1×10^8
Utilities	
Freight transport	10×10^8
Utilities	2×10^8
Urban transit	1×10^{10}
Services	
Business and professional	1×10^9
Government	1×10^7
Financial	2×10^8
Deposit banking	1×10^{10}
Reservations	
Hotels, theaters	2×10^9
Passenger transport	1×10^9
Total	2.9×10^{11}

Source: Client Private.

The results of this survey--approximately a dozen large companies--were organized in a matrix for SRI's use. Companies included were Westinghouse, Southern Pacific, Inland Steel, B. F. Goodrich, Rohr Corp., Bethlehem Steel, Allis Chalmers. Based on the sample data gathered, the following general pattern emerged:

1. These companies started to develop data communication systems in the mid 1960s. Generally the first application of any size was some form of message switching.

2. The pace for system installation was set by available interfaces and telephone channel speeds and services. Most of the equipment and services available ran between Teletype speed and 2400 bits per second.

3. Broadband or high speed services (except for special groups with right-of-way privileges) were limited to in-house or short distance transmission.

4. The computer center generally consisted of 2 IBM model 50s and 65s or the Univac 490 series.

5. Message traffic ran between 10,000 and 25,000 messages per day per system.

6. The systems were nationwide, serving between 100 and 300 cities.

7. The majority of the systems ran both remote and local processing.

8. The large companies have more than one system for data communications.

<u>Industrial Groups</u>. Based on Forbes' 22nd Annual Report on American Industry, January 1, 1970, the following industrial groups are used to estimate traffic figures over the next five years for large industrial groups:

Industry*	Number of Companies (round numbers)
Chemical	20
Information Processing	15
Utilities - Energy	45
Consumer Goods	100
Metals	30
Energy	30
Building Material	20
Electronics and Electrical Products	30
Automotive Products	30
Industrial Equipment	30
Distribution	50
Approximate total	400

Let us assume for the next five years that each of these companies develops three company-wide data transmission systems. Let us further assume that each of these systems handles 25,000 messages per day, with average message length being 200 characters (each character being 10 bits in length). [400 cos. $\times$ 3 systems/co. $\times$ 25,000 mess./day $\times$ 200 chars/message $\times$ 10 bits/char. $\times$ 365 days/year]

Annual Large Company Industrial Traffic $\approx 2.2 \times 10^{13}$ Bits/Year

Summary

Summarizing the six "data points," we find that

1. All the estimates fall within a range between 10^9 and 10^{14} bits per year.

2. This corresponds well with estimates presented in Chapter IV of the report, for individual services or application areas.

3. There is no disagreement between these estimates and the estimates given in Chapter II for total record, data, and private wire message volume.

* Excluded Industrial Groups: Finance, Aerospace, Transportation, Education, and Small Industrial Organizations.

4. Projections of the six services into the future will result in bit rates that also fall within the range given earlier for maximum data transmission volume.

We conclude, therefore, that the methods used in this study are relevant and accurate, and that they meet the objectives of the research.

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Appendix A

LIST OF SERVICES

Appendix A

LIST OF SERVICES

A Comprehensive List of Information Transfer Services

One of the outputs of this study was to be a list of potential information transfer services for the time period of interest. This list is given in this appendix together with SRI's best estimates of the nature or characteristics of each service as expressed by the following parameters:

- Analog or digital
- One way or two way
- Low speed or high speed
- Real time or delayed transmission
- Primarily local or primarily nonlocal usage

The last variable is as a general rule highly speculative, especially for services having no operational history. Very little if any data are available to support these estimates except in special cases, such as the telephone service. It was felt, however, that attempting to describe the probable characteristics of the services would provide a framework for further analysis and perhaps some guidance for the Information Transfer Satellite Concept study, which follows this one.

Data Transmission Applications

While it is clearly not possible to list all known or foreseeable applications of computers and communications in the next decade, SRI has, during the study, performed a search of a large number of literature sources in order to accumulate and identify many of the possibilities. It is clear that this list will represent eventually only a portion of the applications that actually come into being. Furthermore, many of the services listed here may never be established. Thus, the tabulation should be considered only as a list of possible services, with the probability of establishment left undefined.

The general definition or explanation of the column headings is as follows:

Analog or digital. This refers to the basic nature or inherent signaling characteristic of the message or service, as it originates from the source instrument. It does not imply that the message must retain a particular mode of transmission from sender to receiver. Example: telephone and television are considered to be analog services, whereas all record and data services are digital. Also, facsimile is considered to be a digital service.

One way or two way. One way or two way indicates whether, as a general rule, two communicating parties or entities are "conversing": that is, whether the roles of sender and receiver are alternating back and forth during the communication. In one case, messages flow in only one direction at a time; in the other, messages flow in both directions. Example: telephone is two way, telegraph and television are one way. Communications with computers may be either one or two way depending on the nature of the service.

Low speed or high speed. In this categorization, low speed is approximately teletype speed (i.e., 150 to 300 bits per second) and high speed refers to all higher bit rates. In other studies a distinction is sometimes made between medium, or voice-grade, and high speed transmission. These categories are grouped together in the present list.

Real time or delayed transmission. The distinction in this category is in part analogous to the traditional distinction between circuit and message switching; that is, between messages that require immediate or "real time" receipt and those that may be stored and forwarded. As has been pointed out in other studies and articles, this separation is becoming more difficult to justify. Message switching does in fact take place in real time, using computers and on-line storage and retrieval systems; conversely, television broadcasts are circuit switched, but are recorded and later rebroadcast from local stations. With due regard for the lack of precision, the distinctions made should be understood to describe, in general, the urgency or time value of the various services.

Local or nonlocal. Local/nonlocal refers to geographic separation between sender and receiver. As before, the categorization is a general one and not intended to be precise. Within this constraint, however, local may be thought of as comprising the sender's local, nontoll calling area; nonlocal comprises all other areas.

Summarized Services in All Categories

Voice telecommunications	Ana-log/ Dig-ital	One Way/ Two Way	Low Speed/ High Speed	Real Time or Delayed	Local/ Non-local
Telephone	A	2	H	RT	L
Mobile radiotelephone	A	2	H	RT	L
Network radio program transmission	A	1	H	RT	NL
Video telecommunications					
Network television program transmission					
Commercial broadcasting	A	1	H	RT	NL
Educational or public broadcasting*	A	1	H	RT	NL
Video telephone	A	2	H	RT	L
Closed-circuit and other special television services					
Business conferences	A	2	H	RT	NL
Stockholder's meetings	A	1 or 2	H	RT	NL
Sales meetings	A	1 or 2	H	RT	NL
State, local and national political meetings	A	1 or 2	H	RT	NL
Professional meetings	A	1 or 2	H	RT	NL
Educational uses*	A	2	H	RT	NL
Conventions	A	1 or 2	H	RT	NL

* There are, of course, a great number of specific educational uses of television. We have not attempted to identify them individually in this study. We have, however, differentiated between "ETV" and "ITV". We assume the former to be eventually included within the domain of national television networks, broadcasting throughout the nation a

	Analog/ Digital	One Way/ Two Way	Low Speed/ High Speed	Real Time or Delayed	Local/ Non-local
Catalog sales--food stores department stores, motor vehicles, real estate	A	2	H	RT	L
Electronic bussing	A	2	H	RT	NL
Specialized nationwide or regional advertising	A	1 or 2	H	RT	L
Auctions	A	1 or 2	H	RT	L
Electronic touring	A	1 or 2	H	RT	L
Record, data and private wire communications					
Public message telegraph	D	1	L	D	NL
Teletype service (TWX and Telex)	D	1	L	D	NL
Mobile teletype and teleprinter	D	1	L	D	L
Private wire systems	A or D	2	L or H	RT or D	NL
Data transmission*	D				
Written					
Books	D	1	H	D	NL
Magazines and other periodicals	D	1	H	D	NL
Newspapers	D	1	H	D	NL
Postal services	D	1	L	D	L

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given number of hours per day, on the average. We assume on the other hand, that instructional television will normally fall within the domain of closed-circuit or special purposes uses of television. Thus, its inclusion in that category in the above listing.

* This list of applications in this category is given separately on the following pages.

Data Transmission Applications*

Law Enforcement	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Identification of stolen vehicles	2	L	RT	L
Identification of stolen items of identifiable personal property	2	L	D	L
Facsimile transmission of mug short, finger prints and criminal court records	2	H	RT	NL
Gun registration	2	L	D	L
Public order surveillance--riot control	2	H	RT	L
Traffic violations	2	L	D	L
Accident records	2	L	D	L
Missing persons records	2	L	RT	L
Narcotics addicts, etc.	2	L	RT	L
Plant security--checking identification cards	2	L	RT	L
Crime patterns and prediction of future activity	1	L	D	L
Identification records of hard-core criminals	2	L	D	NL
Issuance of license plates or stickers	2	L	D	NL
Collection of fees	2	L	D	L
Citizen assistance in crime detection	2	L	RT	L
Warrants	1	L	D	L

* These services are all digital in nature; thus, the first column ("analog/digital") is unnecessary and is not shown.

	One Way Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Police car and unit locator system	2	L	RT	L
Library Services				
Public	2	L	RT or D	L
Industrial	2	L	RT or D	L
Educational institutions	2	L	RT or D	L
Research	2	L	RT or D	L
Government				
Library of Congress	2	L	RT or D	NL
National Library of Medicine	2	L	RT or D	NL
National Archives	2	L	RT or D	L
National Agricultural Library	2	L	RT or D	NL
Smithsonian Institution	2	L	RT or D	L
Remote browsing	2	H	RT	NL
Interlibrary loans--facsimile transmission of documents and pages of books	2	H	D	L
Automatic cataloging	1	L	D	L
Research and location of material	2	L	D	L
Answer reference questions	2	L	RT	L
Professional consultant service	2	L	RT	L
Distribution of reading lists	1	H	D	NL
Rapid access to documents at remote locations	2	H	RT	NL

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Library service centers	2	H	RT or D	NL
Response and delivery of materials requested	2	H	RT	NL
Medical literature analysis and retrieval (Medlars)	2	L	RT	NL
Collection and dissemination of information on short-lived phenomena	1	H	RT	NL
Education				
Instruction	2	L	RT	L
Instructional management	1	L	D	L
Testing	2	L	RT	L
Counseling	2	L	RT	L
Administrative planning	1	L	D	L
Information retrieval (library services)	2	L	RT	L
Lecturing	2	H	RT	L
Connecting remote campuses	2	H	RT or D	NL
Placement service	1	L	D	L
Fiscal accounting and reporting	1	L	D	L
Instructional problem solving	2	L	RT	L
Text processing	1	L	D	L
Lab equipment accounting	1	L	D	L
Computer-assisted instruction	2	L	RT	L
Interlibrary loans	1	H	D	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local, Non-local
Document retrieval	2	H	RT or D	L
Admissions	1	L	D	L
Registration	1	L	D	L
Banking				
Demand deposit accounting	2	L	RT	L
Savings accounting	2	L	RT	L
Mortgage accounting	2	L	RT	L
Credit card accounting	2	L	RT	L
Loan accounting	2	L	RT	L
Computer services for customers	1 or 2	H or L	RT or D	L
Credit authorizations	2	L	RT	L
Account balance inquiry	2	L	RT	L
Bank management system	2	L	RT	L
On-line customer services	2	L	RT	L
On-line transaction entry	2	L	RT	L
Integrated accounting	1 or 2	L	RT	L
Electronic check clearing	2	L	RT	L
Check verification	2	L	RT	L
Automatic loan payments	1 or 2	H or L	RT or D	L
Lock box remittance	1 or 2	H or L	RT or D	L
Insurance payments	1 or 2	H or L	RT or D	L
Utility billing	1 or 2	H or L	RT or D	L
Professional billing	1 or 2	H or L	RT or D	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local Non-local
Municipal tax billing	1 or 2	H or L	RT or D	L
Rental receipt collection	1 or 2	H or L	RT or D	L
Money transfers between government and public agencies and the private sector (welfare, Medicare)	1	H	D	NL
General ledger and payroll	2	L	RT	L
Management information and control	2	L	RT	L
Investment & Securities Brokerage				
Purchases and sales	2	L	RT	NL
Stock records	2	L	RT	NL
Margin accounting	2	L	RT	NL
Order matching	2	L	RT	NL
Portfolio selection	2	H or L	RT or D	NL
Optimum bond bidding	2	L	RT	NL
Analysts' opinion retrieval	2	L	RT	NL
Stock exchange	2	L	RT	NL
Quotation services	2	L	RT	NL
Cage operations				
Process stock certificates	1	H	D	L
Daily record of stock movements	1	H	D	L
Locate and determine status of a stock certificate in any phase of processing	2	L	RT	L
Instant inventory of securities	2	L	RT	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Determine what stock is available for delivery	2	L	RT	L
Over-the-counter quotations	2	L	RT	NL
Over-the-counter security sales	2	L	RT	NL
End-of-day reports to newspapers and wire services	1	H or L	D	NL
Transaction entry verification and correction	2	L	RT	NL
Data retrieval	2	L	RT	NL
Reports and analyses	or 2	H or L	RT or D	NL
Market trends	1 or 2	L	RT or D	NL
Buy and sell orders	2	L	RT	NL
Inquiries from brokers	2	L	RT	NL
Stock transfers	2	L	RT	NL
General Manufacturing				
Scientific calculations	2	LL	RTD	L
Design automation	2	LL	RTD	L
Engineering calculations	2	LL	RTD	L
Manufacturing engineering	2	LL	RTD	L
Order entry	2	LL	RTD	L
Forecasting	2	LL	RTD	L
Requirements planning	2	LL	RTD	L
Inventory management	2	LL	RTD	L
Production capacity planning	2	LL	RTD	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Shop scheduling	2	L	RT	L
Quality control	2	L	RT	L
Process monitoring and control	2	L	RT	L
Materials handling control	2	L	RT	L
Shop floor control	2	L	RT	L
Engineering plotting	2	L	RT	L
Engineering drawings	2	L	RT	L
Computer-aided design	2	L	RT	L
Text editing	2	L	RT	L
Printing and Publishing				
Advertising billing	1	L	D	L
Circulation accounting	1	L	D	L
Mail subscription processing and accounting	1	L	D	L
Newsprint inventory	2	L	RT or D	L
Typesetting	1	L	RT	L
Cost estimating	1 or 2	L	RT	L
News service dissemination	1	L	RT	L
Integrated classified entry	1	L	RT	L
Book order entry	1	L	RT	L
Letter writing	2	L	RT	L
Press control	2	L	RT	L
Mailroom control	2	L	RT	L
Advanced test editing	2	L	RT	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Petroleum & Industrial Chemical Processing				
Distribution planning	2	L	RT	L
Plant scheduling	2	L	RT	L
Inventory management	2	L	RT	L
Freight rate guide	2	L	RT	L
Process engineering calculations	2	L	RT	L
Project scheduling	2	L	RT	L
Process control	2	L	RT	L
Records maintenance	2	L	RT	L
Oil field automation	2	L	RT	NL
Inventory control	2	L	RT	L
Simulation	2	L	RT	L
Bulk sales invoicing and accounting	2	L	RT	L
Econometric models for management planning	2	L	RT	L
Optimum yield calculations	2	L	RT	L
Wholesale & Retail Trade				
Order entry and processing	2	L	RT	L
Order entry to warehouses	2	L	RT	L
Purchase order control	2	L	RT	L
Remote purchasing	2	L	RT	NL
Sales reporting	2	L	RT	L
Restaurant data collection	2	L	RT	L
Management information systems	2	L	RT	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
On-line sales reporting	2	L	RT	L
Credit bureau reporting	2	L	RT	L
Credit card charge authorization	2	L	RT	L
Credit ratings--opening new accounts	2	L	RT	L
Remote supply centers	2	L	RT	L
Vehicle routing and scheduling	2	L	RT	L
Mail order and billing	1	L	D	L
Freight billing	1	L	D	L
Insurance				
New business processing	2	L	RT	NL
Policy status--maintenance and inquiry	2	L	RT	NL
Estate planning	1 or 2	L	RT or D	NL
Mortgage loan accounting	1 or 2	L	RT or D	NL
Accident and health underwriting	2	L	RT	NL
Accident and health claims	2	L	RT	NL
Endorsements	2	L	RT	NL
Renewals	2	L	RT	NL
Claims	2	L	RT	NL
Alphabetic policyholder index maintenance	2	L	RT	L
Public Utilities				
Customer information system				
Billing	1	H	D	L
Accounts receivable	2	L	D	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Customer inquiry	2	L	RT	L
Credit and collections	2	L	RT	L
Service order entry	2	L	RT	L
Materials management system	2	L	RT	L
General accounting	2	L	D	L
Stockholder records	2	L	RT	L
Construction management system	2	L	RT	NL
Facility planning	1	L	D	L
Electric load flow calculation	1	L	D	L
Short circuit study	1	L	D	L
Transient stability calculations	1	L	D	L
Utility meter reading	1	L	RT	L
Loss formula	1	L	D	L
Rate studies	1	L	D	L
Substation monitoring and control	2	L	RT	L
Plan management system	2	L	RT	L
Distribution management	2	L	RT	L
Economic dispatch	2	L	RT	L
Telephone directory				
Compilation	2	L	RT	L
Daily addendum for operators	2	L	RT	L
Operator rate and route inquiries	2	L	RT	L
Inter-company collect call billing	1	H or L	RT or D	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Remote access computing	2	L	RT	L
Computer-assisted training	2	L	RT	L
Service order entry	2	L	RT	L
Facilities assignment for new customers	1	L	RT	L
Trouble calls and repair records	1	L	RT	L
Customer inquiries	2	L	RT	L
Information operator assistance	2	L	RT	L
Text editing	2	L	RT	L
Transportation				
Air				
Aircraft scheduling	2	L	RT	NL
Network analysis	2	L	RT	L
Maintenance control	2	L	RT	NL
In-flight log analysis	1	L	RT	NL
Automated cargo control	2	L	RT	NL
In-flight function control	2	L	RT	NL
Weather prediction	1 or 2	H or L	RT or	NL
Flight training simulations	2	L	RT	L
Navigation monitoring	2	L	RT	NL
In-flight maintenance monitoring	2	L	RT	NL
Failure prediction	2	L	RT	NL
Corporate information systems	2	L	RT	NL
Crew record maintenance	2	L	RT	NL

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local Non-local
Jet flight planning	2	L	RT	NL
Aircraft performance analysis	1	H or L	RT or D	L
Inventory control	2	L	RT	NL
Reservations systems	2	L	RT	NL
Purchasing	2	L	RT	L
Weight/Balance Optimization	2	L	RT	NL
<u>Rail</u>				
Operations reporting	2	L	RT	NL
Car tracing	2	L	RT	NL
Purchases and stores	2	L	RT	L
Yard control	2	L	RT	L
Freight car scheduling	2	L	RT	NL
Train make-up	2	L	RT	NL
National rail data center	2	L	RT	NL
Diesel diagnostics	2	L	RT	L
Centralized billing	1	L	D	L
Waybilling	1	L	D	NL
Division information system	2	L	RT	NL
Locomotive and train scheduling	2	L	RT	NL
Train control	2	L	RT	NL
Car identification	2	L	RT	NL
Movement of cars	2	L	RT	NL
Loading and unloading	2	L	RT	NL
Car accounting	2	L	RT	NL

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Car location	2	L	RT	NL
Shipper inquiries	2	L	RT	NL
Highway				
Vehicle location	2	L	RT	L or NL
Bus identification	2	L	RT	L or NL
Tracing lost shipments	2	L	RT	L or NL
Pinpointing arrivals and departures of shipments	2	L	RT	L or NL
Freight bill rating	2	L	RT	L or NL
Billing and central rating	2	L	RT	L or NL
On-line dispatching	2	L	RT	L or NL
Terminal control	2	L	RT	L or NL
Preventive maintenance scheduling	2	L	RT	L or NL
Parts inventory control	2	L	RT	L or NL
Inventory control	2	L	RT	L or NL
Remote order entry	2	L	RT	L or NL
Remote tracing	2	L	RT	L or NL
Computer-assisted dispatching	2	L	RT	L or NL
City pick up and delivery dispatching	2	L	RT	L
Dock control	2	L	RT	L
Labor forecasting	2	L	D	L
Engine analysis and diagnostics	2	L	D	L

Personal & Institutional Services	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Medical/Health				
Analysis of electrocardiograms	1	L	RT or D	L or NL
Remote consultation and diagnosis	2	L	RT	L or NL
Patient monitoring	2	L	RT	L
Medical centers in under-developed countries	1	L	RT or D	NL
Billing	1	L	D	L
Dietary management	1	L	D	L
Blood bank records	2	L	RT	L
Shared hospital accounting system	2	L	RT	L
Centralized doctor billing	1	L	D	L
Hospital information systems	2	L	RT	L
Statistical and mathematical analysis	1	L	D	L
Medical information retrieval	2	L	RT	L
Multiphasic screening	2	L	RT	L
Computer-aided instruction	2	L	RT	L
Clinical records system	2	L	RT	L
Adverse drug reaction reporting	2	L	RT	L
Administrative control system	2	L	RT	L
Computer-aided diagnosis	2	L	RT	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Travel				
Airline and other travel reservations	2	L	RT	NL
Hotel/Motel reservations	2	L	RT	NL
Camp site reservations	2	L	RT	NL
Automobile rental reservations	2	L	RT	NL
Airline and other transportation tickets	2	L	RT	NL
Tour planning	2	L	RT	NL
Entertainment				
Ticket sales				
Sports events	2	L	RT	NL
Motion pictures	2	L	RT	NL
Concerts	2	L	RT	NL
Theater	2	L	RT	NL
Home communications				
Shopping				
Supermarket	2	L	RT	L
Department store	2	L	RT	L
Menu planning	2	L	RT	NL
Appointments	2	L	RT	L
Home secretary	2	L	RT	L
Home protection	2	L	RT	L

Federal Government	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
National data systems				
National Crime Information Center (FBI)	2	L	RT	NL
National Health Information Bank (HEW)	2	L	RT	NL
National Legal Information Bank (Justice Department)	2	L	RT	NL
General Services Administration Data Centers (GSA)	2	L	RT	NL
U.S. Geological Survey	2	L	RT	NL
Department of Defense	2	L	RT	NL
NASA	2	L	RT	NL
Personnel records	2	L	RT	NL
Patent and copyright searches	2	L	RT	NL
Legislative status information	2	L	RT	NL
Employment skills retrieval service	2	L	RT	NL
Social security payments				
Medicare	1	H	D	NL
Welfare	1	H	D	NL
Unemployment	1	H	D	NL
Budgeting	1	L	D	L
Appropriation accounting	1	L	D	L
Military operations management	2	L	RT	NL
Project planning and scheduling	2	L	RT	NL
Transportation planning and control	2	L	RT	NL

	One Way/ Two Way	Low Speed/ High Speed	Time/ Delayed	Non-local
Property management	2	L	RT	NL
Maintenance, overhaul, repair scheduling	2	L	RT	NL
Supply and inventory control	2	L	RT	NL
Material storage and transportation processing	2	L	RT	NL
Cataloging inventories	2	L	RT	NL
Weather forecasting	2	H or	RT	NL
Construction estimates	2	L	RT	NL
Internal Revenue Service				
Filing income tax returns	1	L	D	NL
Refund payments	1	L	D	NL
Aeronautical service satellite				
Operational communication	2	L	RT	NL
Surveillance	2	L	RT	NL
Navigation	2	L	RT	NL
Traffic control	2	L	RT	NL
Collision avoidance	2	L	RT	NL
Search and rescue	2	L	RT	NL
Passenger telephone	2	L	RT	NL
Passenger entertainment	1	H or L	RT	NL
Weather advisory	or 2	L	RT	NL
Solar-event advisory	or 2	L	RT	NL
Border control processing	2	L	RT	NL
Immigration	2	L	RT	L

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Health	2	L	RT	L
Customs	2	L	RT	L
NASA space missions				
Manned space missions	2	H or L	RT	NL
Application Technology Satellites	2 2	H or L	RT	NL
Orbiting observatories	2	H or L	RT	NL
Earth resource satellites	2	H or L	RT	NL
Data relay satellites	2	H or L	RT	NL
Other unmanned near-Earth missions	2	H or L	RT	NL
Operational earth resources survey satellites				
Land use survey	1	H or L	RT	NL
Rangeland survey	1	H or L	RT	NL
Crop identification	1	H or L	RT	NL
World timber inventory	1	H or L	RT	NL
Storm tracking	1	H or L	RT	NL
Wind velocity	1	H or L	RT	NL
Global pollution	1	H or L	RT	NL
Mapping	1	H or L	RT	NL
Transportation survey	1	H or L	RT	NL
Urban survey	1	H or L	RT	NL
Mineral/petroleum survey	1	H or L	RT	NL

	One Way/ Two Way	Low Speed/ High Speed	Real Time/ Delayed	Local/ Non-local
Heavy metal survey	1	H or L	RT	NL
Volcanic damagement assessment	1	H or L	RT	NL
Earthquake damagement assessment	1	H or L	RT	NL

Appendix B

PROJECTION OF DEMAND FOR SATELLITE POSTAL SERVICES

Appendix B

PROJECTION OF DEMAND FOR SATELLITE POSTAL SERVICES

Introduction

Among the various ways in which information transfer satellite systems can be used, one is the transfer of personal and business messages that is largely handled today by the postal, telephone, telegraph, and teletype services. At least two plans for using satellites to transmit some of the messages that now use the postal system have been described recently.[1,2*] This analysis attempts to estimate the demand for information transfer by satellite that can be ascribed to "postal" users and services.

In considering this demand area one immediately encounters the problem of definition. Most people would claim to know the difference between a letter, a telegram, and a telephone message; but even today the latter two are becoming indistinct as most telegrams are communicated to the recipient by telephone. In July 1969, the Post Office and Western Union initiated a "Mailgram" experiment, involving the delivery of telegrams by letter carriers. One possible definition would segregate letters as those messages involving physical transfer of paper from sender to recipient. If that definition is adopted, there can of course be no dispatch of letters by satellite. But this is an unnecessarily restrictive definition. For example, it will be remembered that, in World War II, letters were microfilmed and facsimiles delivered (V-Mail). Another definition sees the important difference between mail on the one hand and telephone, telegraph, and teletype service on the other in the fact that letters are collected into large aggregations so that they can be handled in mass, while each telephone, telegraph, and teletype message is individually routed from sender to recipient. This aggregation largely accounts for the lower cost of mail services and, under present technological conditions, for the longer interval between dispatch and receipt of the message. (It will be seen that, of the two proposals to be described, one does and one does not meet the latter definition.)

* References are located at end of Appendix.

Finally, we may define a letter simply in terms of price, as being a message that is transmitted at a cost less than some specified level and whose length can be at least the number of words or symbols that can be typed on a sheet of ordinary stationery. In view of the large current spread between letter and other message prices, the differentiating level can be arbitrary within wide limits, and we shall pick 50 cents (1969 prices). This seems to be the broadest and most useful definition.

We shall first describe two proposed satellite "mail" systems, comment on them, and then attempt to estimate levels of demand for them in the 1980-90 period.

Proposed Systems

Two systems for satellite transmission of letter mail have been proposed recently and will be taken to typify alphanumeric and facsimile transmission systems respectively.

The General Electric System (Reference 1)

The system proposed by General Electric under the name Telemail provides for direct transmission of messages from the sender's to the receiver's teletype terminal via satellite relay. It is therefore more nearly analogous technically to today's teletype than to today's mail. (In addition, General Electric hopes to offer digital data and video transmission services.) . The company believes the price of the service can be progressively reduced; the forecast price for a 600-word message is 33 cents in 1975, 14 cents in 1980, and 10 cents in 1990. This is based on an estimated demand of 1.3 billion messages in 1975, 3.2 billion in 1980, 6.8 billion in 1985, and 21 billion in 1990. Message delivery time is essentially zero. A band width of 87.5 MHz would be required to connect 100,000 subscribers simultaneously. However, two 500 MHz bands are recommended (5925 to 6425 MHz for upward and 3700 to 4200 MHz for downward transmission).

The Lockheed System (Reference 2)

This is a facsimile transmission service to be run by the Post Office, using 100 transmitting and receiving stations that might, for example, correspond to the 100 areas defined by the first two digits of the ZIP code. These would transmit to each other at a rate of 70 to 150 pages per second. A master control would provide for consecutive pairing of the stations. Collection and delivery would be handled conventionally. Privacy of mail would be assured by totally automatic mail handling. An initial price of 15 cents per letter is contemplated, based on a traffic volume of 3,000,000 letters per day. This is 50 percent below system capacity based on a 25 to 50 MHz bandwidth. These numbers refer to black-and-white letterpress or handwriting transmission. Color picture transmission would require a much greater bandwidth or a much lower frame rate. The proposed frequency is in the 10 to 20 GHz range (10 GHz preferred).

No demand study is included in Ref. 2.

Comments

Demand. The estimated demand of 3,000,000 letters per day in the Lockheed system (0.8 billion per year) contrasts with the much higher estimated demand for the General Electric system (based on 1.3 billion messages per year). This may in part be accounted for by the difference in service level. The General Electric system gives instantaneous (0.3 second) transmission while the Lockheed system gives only overnight service. On the other hand, the Lockheed system allows for facsimile transmission while the General Electric system provides only for the transmission of alphanumeric data under the conditions that allow the required number of messages to be sent. Thus, fiducial data requiring facsimile (e.g., checks) cannot be sent. There appears to be some contradiction in the estimates of customer acceptance.

Capacity. Any consideration of the capacity of a satellite mail system must take into account the strongly peaked nature of the demand. The demand for the General Electric system would be high during office hours. On the other hand, demand for the Lockheed system would be concentrated during the night, since most letters are mailed at approximately 5:00 p.m. local time, and the delivery procedure must be started no later than 4:00 a.m. (This includes sorting at the destination.) Thus, at least 75 percent of the volume must be handled during an eleven hour period. Time zone differences may permit a slight extension of this period for west bound mail.

For the Lockheed system we estimate that its actual capacity will be no more than one-half of nominal. Some buffer action is possible here because the letters can be accumulated in waiting stages.[3] For the General Electric system, which requires connections to be made instantaneously, we estimate that the actual system capacity will be no more than one-third of nominal.

On the assumption that an interconnection lasts 3 minutes, the General Electric system as described would then have a capacity of 4 billion messages a year (100,000 simultaneous interconnections x 20 messages/hour x 8 hours/day x 250 days/year). The Lockheed system as described would have a capacity of 1.62 billion messages per year (150 frames/second x 3600 seconds/hour x 12 hours/day x 250 days/year). In each case, the capacity is less than the number of messages required to give the low price assumed.

Estimate of Demand

An attempt will be made to estimate the number of messages that would be diverted from the present U.S. mail system to a satellite system in the 1980-90 period.

Classes of Mail

There are four classes of mail, which may be roughly defined as follows:

First Class - letters, surface and airmail

Second Class - magazines and newspapers

Third Class - circulars

Fourth Class - parcels.

It will be evident that satellite transmission does not apply to parcels, since matter rather than information is transmitted. Circulars are sent at a cheaper rate than letters because time is not of the essence; it will be assumed that they would not be sent by satellite. Magazines and newspapers have urgency; however, it should be recalled that all rates given above refer to short messages (one typewritten page or 500 words), so that rates for transmission of second class mail would be prohibitive.* Evidently, then, attention should be confined to first class mail and airmail.

* Not treated here is the possibility of broadcasting the identical text of magazines to home facsimile receivers.

Forecast of Mail Volume

The most authoritative forecast of mail volume is that made by Arthur D. Little, Inc., as a part of their study for the President's Commission on Postal Organization (the Kappel Commission). It may be stated that this forecast agrees well with projections made by the SRI staff. The Arthur D. Little forecast is included in the Annex to the Commission's report (Ref. 4, pp. 8-2 to 8-5). It takes into account the growth of the population and the economy, but also considers the tendencies towards reduction of mail volume deriving from the growing use of computers (the "checkless society"). This effect, which may amount to 13 percent over the decade beginning in 1968, curbs the exponential rise of mail volume and produces a nearly linear plot of volume versus time. The estimated volume over the 1968-77 period is given as (2t-3890) billion pieces of first class mail and airmail per year, where t is the date in years (Figure 8.1.2 of Ref. 4).

To extend this curve to the 1980-90 period, we must consider the following factors:

1. Growing population
2. Growing real income, abolition of poverty, and hence rapidly growing number of transactions per capita
3. Accelerated substitution of data channels for letters, resulting in an accelerated reduction of financial mail
4. Increased availability of facsimile
5. Relatively cheaper telephone, teletype, and picturephone
6. Probable increase in Post Office efficiency resulting in slower rise of postage rate

On the basis of these considerations, we believe that the volume of first class mail and airmail will dip below the straight line extrapolation of the Kappel Report formula in the early part of the 1980-90 decade, but will rise above it at its end, as shown in the tabulation below. However, the differences between the two columns are well within the limits of error.

	Billions of First Class and Airmail Letters per Year	
Year	Extrapolated	SRI Estimate
1969	48	48
1977	64	64
1980	70	68
1985	80	77
1990	90	92

Fraction of Mail Going Over Large Distances

For any satellite communications system that aims to compete with the existing postal system, there will be a lower bound distance below which it cannot compete successfully. It is not obvious what this distance will be. Clearly local mail will not be relayed via satellite, if only because the station that sends the message up and that which receives it when it comes down will be the same. Equally clearly, transcontinental mail would go via satellite if any domestic mail goes. But how about New York to Chicago? New York to Washington? New York to Philadelphia? New York to Newark?

If we consider the Lockheed system, in which mail is collected and delivered in the conventional way, we see that in any case no quicker delivery than overnight is possible for letters unless there is special delivery. As far as the user is concerned, there is no reason to pay for the special satellite service if he is currently getting overnight delivery. This is now being accomplished over distances of 500 to 1000 miles (though notoriously with rather low reliability). On the other hand, postal authorities might decide to use satellite transmission without regard to user preference if it saved them money. The marginal cost for transmitting a letter by satellite is estimated as 0.6 cents (Reference 2, p. 34--listed as "Facsimile Transmission Rate"). The cost of transporting letters by air is no more than 50 cents per ton mile or (allowing 30 letters to the pound) 0.83×10^{-3} cents per letter mile. Equating these costs, we find a lower limit of 720 miles for satellite transmission. This is a low estimate since letters often average less than one-thirtieth of a pound and air dispatch costs (especially on a space available basis) may be considerably less than 50 cents per ton mile.

The General Electric system, on the other hand, may compete for all nonlocal connections, and we shall arbitrarily assume that it is competitive at distances over 100 miles.

It is not easy to estimate the fraction of letters sent over long distances. Parcels are paid for on a zone basis and statistics of the number of parcels sent as a function of distance are included in the Postmaster-General's annual cost ascertainment report. No such data exist on letters because the required postage is independent of distance. It is necessary to fall back on research studies that give data for individual points of origin. There are a number of listings of address frequencies in studies made by the National Bureau of Standards, and there is a destination analysis in Ref. 4 (Figure 20, p. 877) that will be used here. This analysis refers to mail originating in Detroit in late 1957. It shows that 32 percent of all first class mail (including airmail) was local. An estimated 33 percent was nonlocal, but under 100 miles.

Mail going farther than 720 miles is estimated as 12.1 percent of surface mail, to which must be added nearly all of the 8.65 percent going as airmail, for a total of about 20 percent.

We conclude that maximum demand for satellite mail is 35 percent of all first class mail including airmail if the General Electric system is used and 20 percent if the Lockheed system is used. However, the first figure must be modified to allow for that portion of the mail for which alphanumeric transmission is unsatisfactory. This will include nearly all household-to-household letters, a major fraction of household-to-business and business-to-household letters, and those business-to-business letters requiring "certification" (e.g., facsimile of a signature). Business-to-business letters not requiring certification are about 32 percent of all first class mail and airmail, and we estimate the total fraction of letters that can use the General Electric system at 40 percent. Applying this to the 35 percent going more than 100 miles, we arrive at a maximum demand for the General Electric system of 14 percent of all first class mail and airmail.

In the case of the Lockheed system, it is necessary to exclude (a) long letters (more than one page), (b) letters with enclosures, (c) picture postcards, and (d) other items in which the transmission of the actual written material is desired (e.g., scented notepaper). Of those, item (a) will be by far the most important. No studies of the frequency of one page letters have ever been made, but it is not unreasonable to allow one-third of all letters for these categories. We then come out with a demand of 13 percent of all first class mail and airmail for the Lockheed system.

In view of the uncertainties of the calculation, these numbers are not significantly different. So as not to overstate the accuracy of our calculations, we will say that about one-seventh of the first class and airmail letter volume may eventually go via satellite.

This seems to be a reasonable assumption for the year 1990, for which we then assume a demand of about 13 billion letters. A letter will be equivalent to about 30,000 bits of information if transmitted alphanumerically and about 300,000 bits of information if transmitted by facsimile. The demand for information transmitted from this source would therefore be about 4×10^{14} bits per year for alphanumeric transmission (General Electric system) and 4×10^{15} bits per year for facsimile transmission (Lockheed system).

The General Electric system planners estimate (Ref. 1, p. 27) that 15 percent of the 1990 demand will be attained by 1980 and 32 percent by 1985. If these numbers are correct (and they appear reasonable) the following table may be compiled:

	1980	1985	1990
Pieces of first class mail and airmail	70 billion	80 billion	90 billion
Number available for satellite transmission	10 billion	11.5 billion	13 billion
Percent of available letters actually transmitted by satellite (General Electric estimate)	15%	32%	100%
Number transmitted by satellite	1.5 billion	3.7 billion	13 billion
Number of bits required - alphanumeric	5×10^{13}	1.1×10^{14}	4×10^{14}
Number of bits required - facsimile	5×10^{14}	1.1×10^{15}	4×10^{15}

The General Electric system would require additional capacity and bandwidth, beyond that proposed in Ref. 1, soon after 1985; and the Lockheed system would require additional capacity and bandwidth, beyond that proposed in Ref. 2, soon after 1980. However, if we allow the Lockheed system the same bandwidth (1000 MHz) as is requested for the General Electric system, and allow for duplication of satellites and ground facilities, it can handle the estimated 1990 load. Soon after 1990, technical advances would be required to handle the projected demand.

REFERENCES FOR APPENDIX B

1. Establishment of Domestic Non-Common-Carrier Communication Satellite Facilities by Non-Governmental Entities, and Additional Comments of the General Electric Company, Federal Communications Commission, Docket No. 16495, February 19, 1969

2. Relay Satellite Facsimile Postal System Concept - Preliminary Engineering Study, Report LMSC/A 927096, Lockheed Missiles and Space Company, June 1968

3. Oliver, R. M. and A. H. Samuel, Operations Research, Vol. 10, p. 839, 1963

4. Towards Postal Excellence - The Report of the President's Commission on Postal Organization, Annex, Vol. IV, U.S. Government Printing Office, Washington, D.C., 1968