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Telecommunications: Some Policy Issues; Proceedings of a Task Force Meeting, March 28-30, 1982, Budapest, Hungary

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Tibor Vasko, Editor

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PREFACE

In line with the selected methodology, the Innovation Management Task at IIASA is concentrating on sectors in an attempt to analyze the situation at this level of the economy before making any aggregations or conclusions relevant to management. In order to properly cover industry, it was suggested that branches that are at differing stages or that display different kinds of development be chosen for the study. Telecommunications was recommended as a branch with high growth.

This was the first in a series of task force meetings initiated to promote an exchange of views among researchers and to coordinate the activities of individual collaborating institutions.

A wide selection of issues for discussion are reviewed in the first paper (Vasko), which was circulated to participants in advance. It deals with macroeconomic aspects as well as with sectoral policy issues relevant to innovation.

Prof. Braun's paper deals with basic questions of information related to macroeconomic variables. It particularly points out the volatility of value concepts as related to information and some of its consequences.

The papers that follow deal with the organizational and economic environment of telecommunications. This environment, which was stable for decades, has been disturbed recently by new technology, which has brought with it new economies of scale, new demands, new organizational structures, new time horizons, etc. The paper by Dr. Mueller explores how this has changed the potential for competition in telecommunications.

When asking for resources at a national level, proponents of telecommunications often have to show that the sector can provide social returns comparable to or even higher than those offered by other branches competing for the same resources. Here it is not easy to make a convincing case *ex ante*, which becomes a difficulty especially when we have new services in mind. Similar difficulties are experienced by individual services within the telecommunications branch or even by individual users, as is shown in the paper by Dr. Puzman. No generally accepted methodology is in sight—case studies and their conclusions seem to be the only substitute.

A similar problem is described and suggested for further research by John Page. He concentrates on the interaction of telecommunications and computer-based information technology. Many managerial and policy issues are generated by this interaction and by organizational and operational dissimilarities of these two branches.

The last four papers deal with the relation of telecommunications development to other branches and activities. Dr. Seetzen points out how different technological innovations can be "complementary" to each other in delivering a system capable of new services and/or in offering a new value to the user.

Some potential applications (in information transfer) of these innovations are explored in the second paper by Mr. Page. He shows also how present tariff policies can hamper the acceptance of new services (for example electronic document delivery).

The relations of telecommunications to the printing industry and its potential future development are explored in the paper by Prof. Karttunen. He shows how the progress of information technology in general and telecommunications in particular can influence the graphic arts industry and its progress, giving particular attention to the scene in Finland.

An interesting attempt is made in the paper by Dr. Granstrand. He compares the innovation environment in two production branches in Sweden in which two innovated products have emerged recently--the automobile and telecommunication equipment branches. This comparison serves as a vehicle for identifying similarities and differences in the process of innovation mangement with emphasis on capital formation.

The last paper in the proceedings describes the result of research in videotex systems carried out at IIASA by Drs. Maurer and Sebestyen. The paper presents a technical and economic analysis of the present state-of-the-art and the potential future development of videotex systems with special attention to a comparison of one-way and two-way videotex systems. The authors also try to identify the role of technical innovation of individual components in the system's development with due attention to human and societal factors.

The paper presented by Mr. Nemeth on the use of viewdata systems for inventory control is not included in the proceedings but will be published as a collaborative paper by the institute at a later date.

Tibor Vasko
Task Leader
Innovation Management Task

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CONTENTS

THE PRESENTATIONS

TELECOMMUNICATIONS: THE ISSUES*

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1. Introduction

Telecommunication technology--despite its century-old history-- cannot be labeled a mature industry. It is facing important new challenges generated by recent advances in technology. There have been major changes not only in the physical representation of messages and the media carrying them, but also in the nature of the messages being communicated. Entire information packages are being added to private messages; in the near future, it will be possible to transmit whole information and knowledge bases (Masuda 1972).

Telecommunication enhanced by computers represents the core of information technology, which, it is believed, will stamp the character of future society. It is said that some societies are already reaching this stage (see Parker 1972). Gassmann (1981) has suggested that information technology and services be considered a fourth economic sector.

It seems that every production technology that lent its name to a cultural era in the past better obeyed the laws of economics than does information technology, whose economic and social impacts extend far beyond productivity and production of goods. The effects of information technology seem to be more mediated and indirect, and as a result, more difficult to assess, even when they have been clearly identified.

But this in itself, i.e., identifying the potential impacts (economic and social) of information technology, is very difficult. We might speculate that this might be because information is a companion of creativity. Even in the last century, it was clear to philosophers and economists that creativity defies the bookkeeping (cause and direct effect) character of the majority of economic theories.

This encumbers with many uncertainties the exploration of the role of information in society and makes difficult the accurate forecasting of information demand. And it is from this demand that one must deduce the demand on telecommunications.

*In preparing this paper I was greatly assisted by the comments and suggestions of Alec Lee, Alvin Harman, Josef Puzman, Zsolt Naray, Miles Meriams, Patricia Dinneen, Gordon Thompson, Eric Burke, and other colleagues.

While the following issues address more specific problems, all are related to the general task of acquiring new knowledge relevant to this distinctive sector.

2. The Role of Telecommunications in the National Economy

The easiest way to assess the role of telecommunications in the national economy is to relate it to the resources spent on it (inputs), in terms of both capital and labor. A random glance through the wealth of literature on telecommunications reveals a wide spectrum of data, some of which are somewhat contradictory, mostly because of differences in the methodologies used or in the application of definitions.

Gill (1975) estimates that in the late 1960s investments in telecommunications by PTTs and other carriers ranged from 0.45% to 0.90% of the GDPs of the US, Sweden, the UK and France. In the total of all investments (Gross Fixed Capital Formation) the share of telecommunications in this period ranged from 1.7% in France to 4.0% in the United Kingdom.

This growth trend seems to have continued in the 1970s; at the same time differences among countries have been narrowing. Dondoux (1977) claims that in several countries the share of telecommunications in the GDP has exceeded 10%.

The cost of telecommunication in business is also high. Kimball (1977) indicates that in 1974 DM 22 billion were spent in the FRG on business communications comprising telephones, correspondence, telexing, and business travel. When related expenses for personnel and equipment are included, the amount reaches 12.5 billion (13% of the GNP). Of this sum, 37% is spent on telecommunications, 41% on correspondence.

The labor input is also considered very important. Early in the history of telecommunications it was recognized that some technologies (manual telephone switching, for example) were so labor-intensive that a limited labor supply could hamper the development of the whole sector. This provided a strong motivation for innovation and led to increased substitution of capital for labor. Now labor input is no longer a constraint in the telecommunications sector.

The transmission of information has become very efficient. Perhaps this--together with the general tendency S. Nora calls "l'informatization" of society--has contributed to the major shift of the working population toward information handling activities. In his widely known study, Porat (1977) pointed out that 50% of the US civilian labor force is engaged in information-intensive activities and that 46% of the US GNP is derived from the production, processing, and distribution of information goods and services.

Should information handling (recent computers) proceed the same way as information transmission (telecommunications) did several decades before it, one could conclude that it needs substantial innovation.

Telecommunications have a significant share in all research and development activities. In most countries the financial resources devoted to this activity (as a percentage of sales) is higher than in most other industries (except computers). In the US, for example, the percentage is twice as high as for manufacturing industry as a whole (Agnew, Romeo 1981).

While there may be differences among countries in the levels of inputs to the telecommunications sector, there seems to be a general trend toward higher shares in the use of resources.

The increased importance of modern telecommunications has led to the introduction of the notion of an electronic infrastructure in the national economy whose major component is telecommunications. Kapitonov (1980) contends that in the CMEA countries telecommunications is part of an emerging international production infrastructure. The management of a modern economy requires many coordinated but locally decentralized decisions for which computers and telecommunications are indispensable. In the USSR some estimates were made of how many arithmetic calculations are required per year in the process of managing the national economy during the 1960s. The result was #10 sup 16# (Glushkov 1974).

As for the society as a whole, related data on information handling capability were given by R.N. Noyce (1977), who concluded that there are 50,000 electronic logic functions per capita in use in the US, and that this may grow by a factor of 10 in the next five years. This might lead to a situation in which each person could command the capabilities of a powerful computer.

These considerations do not take into account indirect, secondary, and difficult-to-assess effects of the widespread use of information technology made possible by the availability of telecommunications, such as the enhancement of the creativity of users, the increase in the efficiency of the education process, etc..

Certain impediments appear to be inherent in efforts to identify the impact of this technology, because as it is correctly argued by G.B. Thompson (1979), not only is information as an economic good different from other goods, but the technology connected with it is also unique. If we forget this fact we may miss the main specific contribution of this technology (much as did the one who discovered that when photographic plates are kept close to discharge tubes, they become black and that it might be better to store them elsewhere--to Roentgen this same information was sufficient to discover x-rays.)

3. Innovation Potential in Telecommunications and Its Source

The cost/performance ratio of modern electronic components has led to innovative equipment and services in the telecommunications sector. A case in point is the high rate of penetration of LSI/VLSI-based semi-conductor components in telecommunications equipment. Detailed studies reveal that microcircuits have been incorporated into the design of virtually every major category of telecommunications device (Melvin 1980), including:

- high feature telephone sets (with custom-made microprocessors)

- multiple-line key telephone equipment
- voice/data terminal equipment
- private automatic branch exchange (PABX) switching systems
- subscriber loop multiplex systems
- central office switching systems
- inter-office line and microwave digital transmission systems

LSI circuits frequently combine analog and digital functions in a single device. This reflects the trend toward replacing analog signals with digital ones at the component level, a trend also seen at the equipment and network levels. Worldwide shipments of modems amounted to nearly 400,000 units in 1978; 1,200,000 units are projected for 1983. This indicates an annual growth rate of approximately 25%.

As remote devices become more reliable, the technological trend is toward a decentralization of control in telecommunications networks through an increasing amount of remote intelligence. Improvements in telecommunication technology include digital encoding and digital signal transmission and processing (PCM, delta), greater efficiency in communication media capacity sharing, new switching techniques, fiber optics, and satellite transmission.

Satellites have developed very rapidly since their appearance in 1960. Fourteen commercial communication satellites were placed in stationary orbit in the 1970s and it is estimated that nearly 100 additional satellites were in orbit at the beginning of 1981. There has been a 50-fold increase in communication satellite capacity with a corresponding decrease in cost per circuit per year since the first stationary communications satellite was launched. Bell Telephone Laboratories expects world traffic to reach 2,000,000 satellite circuits by the year 2000.

Compared with classical copper wire systems, fiber optic transmission systems offer large information capacity, greater protection against interception, low error rate (due to freedom from cross talk and electrical radiation), and low cost. However, optical fibers still require special handling and cannot yet fully replace copper wires. The price of fiber optic cable is dropping rapidly: according to a 1979 study by Probe Research, Inc., the price was expected to have declined from US $13,000 per kilometer in 1978 to US $6,700 in 1981. It was predicted that the price of fiber optic cables would drop below the price of copper cables by the end of 1981 at the latest.

There is an increasing movement toward the integration of communication services. This involves integration of functions, e.g., the integration of transmissions with switching techniques and devices, and will eventually enable a unified computer controller network to transmit voice, video, data, and facsimile and in this way, to integrate services as well. This will eliminate the clear technical distinction between telecommunications and computer services.

4. Sectoral Efficiency

The rate of increase in productivity in the telecommunications sector is considered to be above the average rate for all industries and services. For example, in the FRG, productivity in the telecommunications branch (in terms of traffic volume per employed person) increased sixfold between 1950 and 1975. (See Elias 1976.) Overall productivity in the FRG nearly doubled during the same time span, taking into account all factors involved in production. Data from the US convey a similar picture (Agnew, Romeo 1981).

Capital formation plays an important role in the telecommunications sector. Figures vary from country to country, but in general, the share of telecommunications is high. Elias (1976) for example, states that the German Federal Post Office made investments corresponding to one-sixth of all investment in industry in the Federal Republic of Germany.

The telecommunications sector manifests many natural economies of scale that affect the policies and regulations of firms (regulation of monopolies) and governmental agencies within the sector. Whether or not a new technology is introduced will largely depend on the extent to which it can take advantage of economies of scale.

Innovative capacity is also dependent on the size of the firm or the degree of concentration within the branch. The degree of concentration that is optimal for eliciting creative behavior has not yet been established.

An important question that has been studied elsewhere is what is the impact of R & D on productivity and on the efficiency of telecommunications. This question is difficult to answer conclusively for any sector; in the telecommunication sector, which is not easily amenable to standard classification and data collection schemes, it is even more difficult. In addition, regulation makes the real impact difficult to assess. Rates of return on innovations in this sector are very low, perhaps because regulation prevents companies from appropriating the gains of innovative activities (Griliches 1980). This may discourage innovators.

5. Selection Environment

Innovation, the modification of a particular service or product or the introduction of a new one, is largely dependent on economic and social environment. In telecommunications the decision to innovate must be based on consideration of a number of factors that are not always present in other sectors.

This makes predicting success very risky: CB radio succeeded beyond all expectations, for example, while Picturephone lagged far behind. Some researchers argue (see for example Thompson 1979) that in telecommunications only those innovations that have direct effects of the first order and which are related to cost reduction are accepted. Such innovations lead to an intensification of existing processes. Extensive innovations involving impacts of a higher order do not seem to work. Knowledge about this is still very inadequate.

The worldwide telecommunications system with its more than 500 million telephones is the largest man-made machine, a machine that should be designed to meet the criteria of effectiveness and reliability. The implementation of any technological change in this system must take into account

- amortization requirements of equipment currently in use
- the compatibility of the technical innovation with the rest of the network
- the revenue requirements of the new technology
- the needs of the user
- policy regulations
- personnel requirements (increased or decreased) and training
- the market situation, standards, CCITT recommendations, etc.

These factors create an environment that complicates the selection of a particular innovation from the set of potentially available ones. A new consideration has been added quite recently: the consumption of energy and resources by new telecommunication services. An overview of the relevance of this criterion is given by Maurer, Rauch, and Sebestyen (1982).

6. The Relation of Telecommunications to Other Sectors

The telecommunications sector has close links with other sectors of the national economy, especially manufacturing, and particularly in recent years, the computer industry. Telecommunications makes it possible for users to access remote data bases and also facilitates the creation of distributed data processing networks.

Microelectronic components have functionally replaced electromechanical devices and hard-wired control, increasing telecommunications' flexibility and reliability, as well as improving its performance/cost ratio, especially from the point of view of service vendors.

As the price of energy has increased, telecommunications has become a potential instrument for promoting energy conservation, by improving the efficiency of transport, and in some cases, by partially replacing it. Energy saving has become one of the objectives of innovation and policy design in telecommunication (Day 1978).

The effects of telecommunications are also felt in the administrative branch, where the so-called "electronic office" may radically change the way offices operate. The "office of the future" features

- teletex service for inter-office correspondence (with high transmission rate, ISO-7 codes, automatic distribution, and automated receiving)
- electronic mail, based on computer control and processing, with "store and forward capability"
- centralized filing, with remote file access

- teleconferencing, etc.

The introduction of electronic fund transfers will have a significant impact on banking, and will create new problems of reliability, privacy, security, etc.

7. The Policy Issues

The specific properties of telecommunication named above are making the design of an optimal policy (assuming we know what the criterion for optimality is) very difficult. These properties seem to trigger off policy issues unlike those economist and policy makers are accustomed to facing.

Telecommunications are regulated in virtually every country, although there are significant policy differences among nations. The oldest regulations affecting the telephone industry are in the US, where rate-level regulation is used. The limited range of this regulation has been acknowledged and discussed for more than half a century. New and hopefully better methods are now being sought, but the diversification of telecommunication services makes the choice difficult. In addition, regulators are faced with a lack of sufficient information (Ryan 1981).

One could list several recent changes in the nature of telecommunications that have increased both the importance and complexity of policy issues. What was once an established regulated monopoly has now become one of an expanding set of related technologies. The character of the demand for telecommunications has also been changing. For quite some time it was homogeneous in nature; now it is becoming more and more diversified. There are new uncertainties caused by new technologies and system patterns. There are uncertainties about economies of scale. The boundary lines between systems are becoming more uneven and less well defined than before. New technology is also causing a proliferation of substitute equipment, which is creating competitive alternatives where these forces were once relatively small.

Telecommunications policy issues inevitably involve economic matters. Social aspects are becoming increasingly involved as well. Ideal perhaps, would be to identify and implement innovations that are technically possible, economically attractive, and socially useful. But such an accomplishment would be very difficult, perhaps infeasible. Instead the problem may be one of trade-offs.

Some important technical policy problems relate to standards. In telecommunications, where the exchange of information involves not only interstate links but also international ones, standards (generally established as CCITT recommendations) become essential and are not entirely within national control. These standards apply to interfaces at the borders, and include performance capability.

At the level of the national economy, the policy issues include

- the management of the telecommunications sector development in the scope of the national economy

- the priority to be given to telecommunications in the economic and social development of a country
- what services to introduce, and when to do so; what measures to use to stimulate development in the desired direction
- how to do this in a technically "turbulent" environment, in which many decisions are burdened with risk

Important social issues includes the effect of telecommunications on

- lifestyles
- labor force, jobs, etc.
- crime control
- privacy

As important as the formulation of policies are the instruments for implementing them. This is important because many new telecommunication services (e.g., services aimed at educating or at enhancing public participation) are not compatible with the traditional market.

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SOME REMARKS ON THE ECONOMICS OF INFORMATION

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1. Introduction

A high and increasing proportion of total economic activity in advanced countries is related to the creation, manipulation and dissemination of information. If we are to believe that we are becoming an information society, then information must be at the very heart of our economic activity. Yet our understanding of basic economic relationships with regard to information is infinitely poorer than that for other subjects of economic activity, such as the production and marketing of manufactured goods or of primary products. The present paper considers some of the obstacles to our understanding and aims to suggest some avenues towards overcoming them.

If we regard information as a trading commodity, as in many ways we must, it becomes immediately obvious that it has some curious properties, of which we shall list but a few.

i. Information is difficult to define and covers a multitude of sins, from tables of logarithms to Shakespearian drama.

ii. It may be hard to measure the cost of production of information, yet to measure the benefit (or cost) of consumption is well nigh impossible.

iii. Information is a free good in the sense that the resource remains undiminished after its consumption, yet its exclusive possession is frequently highly prized (see e.g., Taylor and Silberston, 1973).

iv. Much information is created in the public sector, often as a public good, and there is great unease at the boundary between public and private activities.

v. As the value of output is impossible to define, so the efficiency and productivity of the whole information sector must remain undefined. In view of the fact that this sector comprises more than half the economy (Porath 1977), lack of knowledge about its productivity might be regarded as a serious deficiency.

2. Definitions of Information

In what we might call the statistical definition of information, any distribution of any quantity which differs from the expected distribution conveys information. A written word contains information because the letters describing it are not randomly distributed. On the other hand, information on an individual event or item is conveyed by describing its position in a distribution; e.g., a person's income is information even when the income distribution is known and therefore, under some conditions, a statement of the average earnings of a large number of individuals contains no new information. The descriptions of the color of eyes or hair in a European passport makes sense, in a Chinese or Indian or Ugandan passport it is meaningless. This treatment of information has a great deal of utility in thermodynamics and in economics (see e.g., Sommerfeld 1956 and Theil 1967), but it tells us little about the economics of information. Besides, it tells us very little about many types of information which play an important role in our economic activities.

An alternative definition of information is "an input which alters the probability distribution of events in the perception of an individual or an organization". In simple though less accurate words, information is something that reduces uncertainty, although it might also increase it. There must be doubt about the general validity of this definition, because it leaves out some important categories of information.

3. Types of Information

A. Strictly factual and expressed in numbers or other symbols--with small amount of text sufficient to make the symbols meaningful (though sometimes requiring a good deal of background knowledge), e.g.,
   - Actual weather over past period
   - Airline bookings
   - Mathematical tables
   - Library card index
   - Railway timetables

B. Factual and expressed in numbers or symbols, but with complex explanations, definitions and methods of measurement, sometimes involving theoretical relationships which cast doubt upon the validity of the facts, e.g.,
   - Distribution of income
   - Composition of chemicals
   - Gross national product

C. Simple information of type B (or occasionally A) but projected into the future and thus entailing varying degrees of uncertainty.

D. Simple factual information in words, though these are often used in a Pickwickian sense, meaningful only to the initiated, e.g.,
   - Theatre programmes
   - Sales catalogues
   - Lists of parts

E. Topographical information in principle expressible in numbers and symbols, but comprehensible only in visual images because of the high density of information required for an adequate description. Examples might include:

- Anatomical atlas
- Maps
- Drawings of parts
- Photographs of landscape, people or objects

F. Verbal information of high factual content where relationships between parts of a system or situation described are as important as the parts themselves and are required to give meaning to the description as a whole. Depending on the complexity of the system, there can be a high degree of selectivity and therefore some variability of interpretation of the facts. Examples might be:

- A description of the management structure of a large firm
  Most papers in scientific journals
  Factual reports in newspapers

G. Similar to F, but with a shift of emphasis from factual description to interpretation, opinion and forecasting, e.g.,

- Leading articles in newspapers
- Many papers in social science journals

H. Texts mainly intended for entertainment or the contemplation of broad relationships, e.g.,

- Literature
- Drama

I. Similar to H (or sometimes F) but catering either entirely or additionally to the sense of hearing or of vision, e.g.,

- Music
- Film
- Theatre

J. Skill--information which can only be acquired by practice and which cannot be fully conveyed by any information medium.

Information is clearly a multi-variable activity and a proper description would require placing a particular type of information in a segment of a multidimensional space. Some of the variables of such a space might be:

- Size of audience
- Accuracy and reliability
- Temporal qualities
- Relevance to economic activity
- Pleasure
- Consensus over quality
- Originality
- Ease of access

Perhaps the most important classification of information may divide it into just three classes according to end use.

i. Information as an item of final consumption

ii. Information as an input to other economic activity

iii. Information as an input to other non-economic activity

Examples of the first type would include artistic and entertainment activities. We read a novel for the pleasure of it; the 'consumption' is an end in itself. The second type clearly includes all information activities within a firm, such as planning, accountancy, personnel records, research, legal activities. The third category is perhaps less important and would include such items as reading holiday brochures with the purpose of planning a holiday, although clearly an economic activity by the operator is involved; the client's final consumption is the holiday and not the brochure.

One problem that arises out of this classification is serendipity. Information obtained without any intention of economic utilization, say an observation made on holiday, may trigger off a train of thought leading to the establishment of a new business. It is this 'browsing' quality of our intake of information and the amazingly tortuous ways in which circumstances audacious to a particular activity arise that make it impossible for any information system to be perfect. For we can, at best, only supply known needs--new needs arise out of new constellations. There is a kaleidoscopic, foraging quality about our intake of information, which runs counter to all systematic attempts at designing perfect information systems. In this sense, and this sense only, we must agree with Hayek (1945), when he speaks of the irreplaceable information on "circumstances of time and place" which militates against centralized systems.

We must, however reluctantly, reach the conclusion that a high proportion of information cannot be given an economic value--it is truly priceless--and yet it is such freely circulating information coupled with the imaginative observer which makes the cultural, social, and economic wheels turn round. We must regard the free availability of a vast variety of information as a public good of utmost importance. If the world is a stage, then a kaleidoscopic shifting pattern of information is the backdrop needed to unfold the play.

Having thus opted out of giving an economic value to much of the most valuable information activities, we must turn to those items which can be valued more effectively.

4. The Economic Value of Some Information

If we define value as the total price the market is willing to pay for a particular item of information, as we must, we run into three difficulties. The first is the definition of an item of information. We shall side-step this by taking an item as whatever package the information comes in: a consultant's report, a book, a journal article, a balance sheet, a patent. The second difficulty arises out of the possibility of multiple sales. A book may sell in thousands of copies over many years; a licence to use a patent may bring royalties over the life of the patent; the consultant's report is the only one of our examples which is sold once only, somewhat like a material good. The third difficulty is the ease of piracy. A journal article can be copied many times over and despite all the legal niceties, the photocopier and the tape recorder really have made nonsense of some proprietary rights in information.

Because of the above difficulties, we must distinguish between three kinds of value:

i. The total price the market is willing to pay for the information—we call it the total market value.

ii. The total value the originator of the information can appropriate to himself--we call it the proprietary value.

iii. The indeterminate and intangible value of the item of information as an economic input.

We must now examine the various categories of information for criteria which give them economic value.

Taking the category of information intended as items of final consumption, there is no doubt that the value of the information is related to one property and one property only--popularity. If we examine the total market value of a book, a song, a symphony, a poem, or a play, it is related purely and simply to the price individual consumers are prepared to pay and the number of such consumers (Thompson, 1981).

The proportion of the total market value appropriated by the originator, the proprietary value, varies greatly. It is zero for a long dead author or composer, millions for the best selling author or song-writer, and very little for the author of a learned treatise. The message is indeed not the medium. For while a pirated tape may contain the same message as the legitimate one, the ratio of market value to proprietary value becomes infinity. Similarly, the marginal utility of re-calculating a log table or re-writing *Othello* is zero, yet re-printing of these may be an entirely sound commercial proposition.

We postulated that the market value of information as an item of final consumption is related to its popularity. But popularity is one way of expressing perceived relevance, a consensus on high relevance, and we shall argue that relevance is a major criterion in determining the value of all information.

If perceived relevance is to be a major criterion for assigning value to information, we must examine the concept in a little more detail. Clearly the marginal utility or relevance of knowledge of a source of potable water is infinite to the man dying of thirst and very small to the average city dweller. This is a case where the marginal utility of information leading to a commodity is closely related to the marginal utility of the commodity itself. We can generalize from this commonplace example to say that the value of information used as an input to an economic activity is closely related to the value of the activity itself and to the importance the information plays in it. Thus if I expect to make a million pounds out of manufacturing and selling a superior mousetrap, a patent covering its design may be worth quite a lot to me, as may be the knowledge of some quirk in the behavior of mice which makes my trap work. On the other hand, all information on the mating habits of mice may be quite irrelevant and worthless, as may be many hundreds of patents covering a variety of designs of mousetraps. This is blindingly obvious until we consider a major difficulty (apart from the obvious one that my market estimate may be wrong)--how do I know which patent and which quirk of behavior are important to me? If we exclude the possibility of divine guidance, two ingredients are essential--I must read widely about mice and about methods of controlling them and I must connect two previously unconnected items of information, the patent and the quirk of behavior of mice.

Trivial as the above example may be, it highlights the difficulties of making information relevant and therefore valuable. Not only do we not know the utility of an item of information till after we have consumed it; we often only know it when, by some chance or creative act, we have brought the item of information into a constellation of other factors in which it may play a key role. The marginal utility of an item of information depends on circumstances of time, place, conditions, and other items of previously unrelated information. We may have to absorb masses of irrelevant information in the hope of finding something we need, often not knowing in advance what it is we need.

The price we should be willing to pay for an item of information is related to our expectation of the economic return we may derive from it. The real utility of the information may range from full certainty (I know that I need the instruction manual for a machine in order to use it) to total uncertainty. The cost of consumption of information* may thus range from a necessarily incurred cost to a highly speculative investment.

It is the reduction of uncertainty of relevance which is the main task of information services and consultants. The most common situation for a consumer of economically useful information is the knowledge that what he needs exists somewhere, hidden amongst hundreds of thousands of words and a myriad of tables. Sifting and preparing the information for a particular perceived need--possibly making some judgment on its reliability as well--is the economic activity of the information scientist. This task is made much more difficult by the sheer mass of information available and computers were supposed to make the sifting so much easier, but we must greatly doubt whether they have helped substantially. The consultant's fees must be regarded as part of the cost of consumption of information, as are all the mechanical or electronic aids for dealing with it. Information suffers a high degree of congestion costs.

5. Dissemination of Information

The mode of dissemination of information varies with the number of people to whom it is relevant and with the temporal qualities of the information. Thus general news is broadcast not only because it is relevant to a large number of people, but also because it is ephemeral--words writ on the television screen. Similarly relevant but more or less permanent information, the durable of the information business, is recorded in what we might loosely describe as handbooks: tables of physical constants, collections of laws and regulations, telephone directories, Who is Who.....

*I am indebted to Stuart Macdonald for drawing my attention to this important concept, which includes the cost of reading, storing and marshalling the information concerned.

The aim of systems like 'Prestel' is to bring information of varying durability, relevant to large numbers of people, onto the television screen. If updating needs to be done fairly frequently, it is much cheaper than re-printing handbooks. If the information is truly readily available through clever algorithms, then its use is more convenient than that of handbooks normally found only in libraries, and a larger range of information of varying degrees of fleetingness, from news to theatre programmes to railway timetables to the Oxford Dictionary, can be incorporated. This activity could be wealth-creating if, and only if, the price paid by the customers for the use of the information is higher than the cost of providing the service.

The economics of a selective broadcasting system thus depends on a critical balance between the cost, the convenience of use, and the perceived relevance of the available material. The outcome must be regarded as indeterminate at this stage, but the factors which will determine it are clearly discernible.

By the very nature of a selective broadcasting system, only some types of information can be disseminated in this way. In fact, only the types we have called A and D (simple factual) are readily amenable to this treatment; other categories would only exceptionally be considered. Without wishing to belittle the importance of types A and D of information, it is clear that only a small segment of the totality of information can be fully computerized in this way. Furthermore, only such information which is relevant to large numbers of people can be broadcast. Thus we are left with vast amounts of information which cannot be economically disseminated by systems such as

Computer information systems need not, of course, work in conjunction with a broadcasting system. Indeed perhaps the most important applications are within commercial organizations where stock control, accounts, lists of parts, machine scheduling, patent files, design data, and much other information are held on computer and made accessible on display devices within the organization, possibly in widely dispersed locations. The economic value of this type of activity is extremely hard to gauge. Because the information is not an item of final consumption and because the quantity and quality of information required are indeterminate, the economic value remains indeterminate. A balance must be struck between such items as: how much time is saved by providing the information in one form rather than in another; how much value does the information add to the final product; what is the cost of collecting, holding and disseminating the information; what is the cost of unnecessary use of the information; what is the degree of certainty of relevance; is serendipity catered for and, if so, at what ratio of actual cost to likely benefit? The possibilities of answering these questions range from difficult to impossible; yet we must know these answers if we are to optimise, in the economic sense, an internal information system.

Even the systems of the kind described above will cater mostly for information needs in categories A and D, though B,C, and some of E and F can be added. The main problems concerning these types are access through suitable classifications and algorithms, cost effectiveness, and catering for serendipity. Certainty of relevance can be high for information with high factual content. The types of information suggested on pp. 3-4 can be examined from that point of view and we find that types A to F can be readily ranked by a potential consumer into a few simple categories of relevance. The more verbal and speculative the information becomes, the more difficult it is to rank it into relevance. This point is crucial, for the marginal utility of incurring the costs of consumption of information is proportional to its relevance. Hence so much effort is devoted to computerized access to types of information which are not readily amenable to this treatment. Can we really guess the relevance of a Ph.D thesis from the pathetic little list of key words?

6. Summary and Conclusions

1. The term information is too broad and ill defined to be treated by a single theoretical approach. Several ways of classifying information have therefore been suggested.
2. There is no new economic problem in relation to information as an item of final consumption, except that new technology has caused new difficulties in the appropriation of a proprietary share of the market value. Some information activities--and much educational activity falls into this category--are items of final consumption, yet are also a general input into economic activity. This type of information must be regarded as an essential public good and its free availability is vital to the functioning of the economy.
3. The economic value of information used as an intermediate input into economic activity depends upon its relevance and the market value of the final product. Much information of this kind is produced in the service sector and sold at a known price; much is also produced internally within organizations at a calculable cost. The assignment of benefits from such information is problematic.
4. Computers can help to improve access to some types of information and, depending upon its relevance, can help in selective broadcasting. Large categories of information elude this treatment.
5. The cost of consumption of information can be high and there are considerable congestion costs associated with it.

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THE POTENTIAL FOR COMPETITION IN TELECOMMUNICATIONS

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INTRODUCTION

In this paper, the results of a larger report on the potential competition in the telecommunications sector is summarized and expanded upon. It is suggested that an increased use of market allocation could be pursued, especially for terminal equipment. Under certain conditions the PTT should be able to participate in this market as well.

The paper stops short of suggesting outright competition in the network. First, because the issue requires further analysis, second, its implementation would be very difficult to carry out in Western Europe, given the current institutional arrangement. Some form of network competition--in the form of shared use, resale and value-added networks (VAN) should be permitted, however.

We first look at the increasing application of telecommunication services and discuss the potential for competition, as it is apparent from the recent experience in the USA. A discussion on the benefits of competition--even in publically regulated or publically owned sectors follows. Then the potential for network and terminal equipment competition is discussed in detail and rules for such competition are developed. This includes some role for the (traditional European) PTT in such a more competitive environment, including both constraints on conduct and a move towards a more cost oriented tariff structure.

TELECOMMUNICATION SERVICES

Telecommunications refers to electronic signal transmission between senders and receivers with the possibility for instant feedback (conversation). This potential may not always be used, but it is nevertheless an important distinction from one-way electronic communications, like public broadcasting. It implies a need for input and output devices on the sending and receiving end (terminal equipment) and for transmission equipment between them. Since transmission, for economic reasons, usually occurs over a network, rather than a single dedicated line between individual participants, switching is important as well. While in the past such telecommunication networks have been used for single purposes only (such as voice, via the telephone network, or telex) it is important to note that today, many other input and output devices are possible for such information-carrying media as data, text and image. The traditional human voice and listening capability is therefore only one of the many input and output devices.

To summarize the telephone system normally consists of:

1. Transmission facilities, including all local lines and cables--local outside plant--and long-haul equipment--trunk cables, microwave links, repeaters, satellites and earth stations, electro-optical devices, and other advanced media--and the related carrier and multiplexing gear.

2. A hierarchy of switching centers which include local, trunk and international exchanges, as well as private automatic branch exchanges (P.A.B.X.).

3. Subscriber apparatus or terminals, mainly including mainstation telephones, but also other input and output devices, such as teleprinters, visual display units, facsimile devices, communication typewriters, etc., and modems for signal conversion.*

Telecommunications has traditionally been seen as a natural monopoly sector. By this we mean that the cost-minimising industry structure serving a particular market is a single firm.** For this reason, telecommunications services have been shielded from competition; they have been either publicly regulated private enterprise services, or, as is especially common in Europe, run by State-Owned Enterprises, commonly called PTTs. Historically speaking, most of the national telephone services have originally been established through licences from the relevant local authorities to equipment manufacturers, who were vertically integrated, providing this service as well (Altman, 1977). Because of the natural monopoly argument, and also because of the strategic role of national telecommunications services, the role of the State in these sectors has been very dominant, and competition has only been allowed to take place within a very restricted framework.

*In addition to this fixed-plant telephone and telegraph equipment, there are also mobile radio systems--often connected to the terminal end for paging or radio telephone services. Radio dispatch systems also belong to this group, even though they may be private, insular systems.

**However, see Baumol, 1978 for a more thorough definition.

INCREASING SIGNS OF COMPETITION

Vertical Disintegration

Whilst in the past, and especially in the U.S. and Canada, vertically integrated structures, (which comprise equipment producers and network operators, as for example, the Bell System but also GTE and Bell Canada-Northern Telecom) have been the dominant form of industrial organization, recent attempts to reduce the foreclosure created through vertical integration are apparent. The Court proceedings in the most important case (USR vs. ATT, 1978) will result in substantial vertical disintegration. In other instances an increased separation between network operation and equipment manufacturing is already becoming apparent.*

In Europe, except where equipment manufacturers are also network operators under licence from their respective Governments (for example, until very recently Spain, Italy and before the War in Hungary and Poland, etc.), this issue of vertical integration has never been important. Instead, the network operators have been separated from the equipment manufacturers, even though they have at times had almost a quasi-vertical relationship. They usually relied on a number of trusted national suppliers, so that these markets were pretty well closed off too, both nationally, and internationally.**

*See the ITT-GTE Consent Decree, for example.

**The British term for this relationship is "The King", in German it is called a System of Court Suppliers--"Hoflieferanten".

But even here the EEC is attempting to open the markets at least European-wide.*

Terminal Equipment

While the market for switching and transmission equipment may become more competitive through vertical disintegration, the competitive effects seems greatest in the market for terminal equipment. That competitive allocation seems possible, has been demonstrated in the USA by the recent Carter-Phone decision and subsequent Equipment Registration Programme,** which allowed certified equipment to be connected directly to the network. The benefits of this programme are recognized and may be one reason for similar policy proposal in the U.K. (Peye, 1979).

In Western Europe some form of competition in the terminal equipment market has always been possible under the guidance of the PTT, in West Germany already since 1902 (Mestmäcker, 1980). The guidance and control of the PTT has at times been very restrictive, however. Only if this is reduced to some minimum standard are similar results to be expected, which we observed in the United States (Müller, 1979). The European Commission has recently taken up this challenge.*** But it remains to be seen, under what conditions increased competition in that market is possible, and if the expected benefits are as large as we have observed them in the USA.

Competition in the network also seems to be possible. The US has certainly moved in this direction, with its "above 890 decision", the "open sky decision", the specialized common carrier decision, the "execunet decision", etc.**** Also in Canada, the traditional telegraph and data service of the railroads (CP/CN) has been allowed to interconnect with the national telephone network, therefore providing direct network competition. These policies have partially caught on in Europe, (i.e., Project Mercury in the UK) and the issue for increased competition is equally apparent.

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*See, the survey of the EEC's telematique plan in The European Community, December 1979, p.10.

**See for details Müller, 1981.

***See EEC, 1979.

****See Müller 1981.

ECONOMIC ISSUES: THE ROLE OF COMPETITION IN REGULATED MARKETS

The above mentioned tendencies seem to indicate that different systems of organizational forms for the provision of telecommunication services are possible, from a move to a deregulated situation in the USA to the European approach, where all services on one hand is the norm. The question is, can we, as economists, say anything relevant on these issues? What recommendations would we be willing to make?

At the outset, let me state four points:

a. From my own background on the study of regulated industries, I have always found the introduction of competition beneficial as far as static and dynamic efficiency is concerned. (See Müller and Vogelsang, 1979.) For this reason, I would tend to argue to allow as much competition as possible (see also the arguments in Müller and Vogelsang, 1978).

b. Competition, even in regulated or public enterprise type environments, has helped to push dynamic performance and innovativeness. Not regulatory change, but the threat of entry and competition have helped to bring about the introduction of innovative services. What regulation or Government intervention has normally done, is to slow down such innovations and protect those benefitting from the status quo. (See Owen and Braeutigam, 1978, Posner, 1975).

c. Increased competition helps to de-politicize public enterprise prices and leads to the quicker adaption of increased service variety.

d. Increased reliance on cost-based or cost-related prices (which we normally expect as a result of increased competition) improve the allocative efficiency of markets. For this reason, we would also argue to let markets control allocations as much as possible.

Normally, or at least according to text book economics, governments intervene in markets because of partial or total market failure. In the latter case, we have little chance for market control, (for example with the absence of property rights). But with partial market failure, some reliance on market forces may be possible, even in the case of economies of scale, externalities, etc. The uses of taxes or subsidies would be examples of such intervention. In the telephone industry, the granting of legal monopoly has often been used to avoid duplicative network structures. At the same time, tariffs have been controlled to avoid monopolistic profits. But as political economists, we often observe that government intervention is not only carried out to correct market failure, but also often to achieve other goals, mainly of the redistributive kinds. Equal charges for access, independent of cost, or public service type provisions are therefore the rule.

Such uniformity of tariffs (or a rate-averaging) could also lead to entry in natural monopoly areas, where the threat of entry normally ought not to exist, except for the cases mentioned in the so-called 'sustainability literature', (Panzar and Willig, 1977 and Baumol, Bailey and Willig, 1977). It is mainly due to cross-subsidization (to achieve certain redistributive goals) that competitive entry is possible.* It does not necessarily take place because of the superior performance by the new entrant (either through improved productivity or new, innovative services of the product innovation type), but because of cream-skimming by the entrant. This would be socially inefficient, because if economies of scale are really so large that a natural monopoly is the result, wasteful duplicative investment in infrastructure would take place. In addition, the surplus generating activity, which is needed to carry out the cross-subsidization is reduced as a result of competitive entry and the potential to cross-subsidize eliminated.

Therefore, while competition in "idealized markets" (Willig, 1979), may force firms to be efficient producers, the beneficial effect of competition for State Owned Enterprises, or other regulated firms, which pursue other goals in addition to the efficient allocation of resources, is less obvious.

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*I would argue that social, regional or administrative goals in pricing structures are a much more important reason for "non-sustainable" price structures than the arguments made in the original sustainability literature.

We must therefore be very careful in interpreting the results from such competition. Successful entry may not necessarily be a sign of inefficiency, or the dwindling importance of economies of scale, but one of cross-subsidization. On the other hand, this point may also indicate that the current practice of prohibiting competition only to allow cross-subsidization may be a very inefficient policy of redistribution. First of all, it prevents the competitive threat, thereby increasing to bureaucratic inefficiency, etc. Second, the fact that cross-subsidization may be more efficiently carried out with separate taxes and subsidies ought to be kept in mind as well.

With this background let us now look at the two kinds of competition which we have been talking about, competition in the network and competition for terminal equipment and analyze the empirical evidence available.

NETWORK COMPETITION

The telecommunications sector has, as mentioned previously, been normally characterized as a natural monopoly. Its network characteristic, especially with respect to the local network, seem to support this point. Estimates of economies of scale for telephone systems indicate scale elasticities in the neighborhood of 1.2 to 1.25.* On the basis of this, and under the assumption of no cross-subsidization, we would therefore not really expect the treat of efficient entry to materialize.

But there are importnat counter arguments:

a. First of all the economies of scale are different in each subpart of the system, thereby allowing for efficient entry in some markets to take place.** For example, the economies of scale for transmission services have been reduced with the introduction of wireless transmission systems, like microwave services and even more recently, direct broadcasting satellites (see also Waverman, 1975).

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*See Charles River Associates, 1979, p.193 for a summary of the relevant studies.

**See also Ellis, 1975 for scale estimates in subparts of the system.

Apparently, at least for point-to-point communication along direct routes, economies of scale are exhausted very early and duplicative services would not be inefficient. Of course, the technology is continuously changing, and one needs to analyze this question in detail.* At the moment, competition for inter-city services, transatlantic routes, etc., seems certainly possible, and economically efficient. The introduction of wireless communication techniques has strengthened this point.

b. With local networks, and 80% of cable installation is with respect to local networks, the economies of scale seem still important, preserving there a natural monopoly. But even here, there are signs of technical change towards the potential of increased competition. One reason is the potential of a direct satellite link for large customers at competitive rates.** The other is a potential for radio links in the form of cellular systems.

On the basis of these changed technological characteristics, one may conclude that competition in the network seems possible. The US seems to be moving in this direction, as is evident by the recent regulatory history (Müller and Vogelsang, 1979, Müller 1981) and the current legislative proposals to change the Communication Act of 1934. But if one moves in this direction some guidelines will have to be established, to ensure compatibility, reliability and the avoidance of duplicative investment. The threat of ruinous competition certainly looms large with the capital cost being such a high proportion of the service costs.***

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*For a while, it looked as if wave-guided transmission lines would have such enormous economies of scale properties that the natural monopoly characteristic would be restored. But this development has now been surpassed by glass fibre technology, whose implications are still open.

**Largely because the prices for receiving antennae has decreased remarkably over the last few years from roughly $1000,000 (US) in 1975 to $999 today (Irwin, 1980, p.15).

***But guidance may be drawn also from the discussion about increased competition in the electricity industry (Weiss, 1975).

In Europe, except for the recent UK decision to allow one alternative network (project Mercury), there are few signs apparent of moves in this direction, despite the same technological tendencies. We reserve our judgement on much a move for the moment. Nevertheless we should prepare such a decision with detailed background studies and an analysis of the US and the Canadian situation to determine to what extent such moves are politically and economically opportune. We do, however, recommend already now the possibility of shared use and resale of network services via so-called VAN (value-added networks).*

A major casualty of such a system would be the cross-subsidization currently pursued under a uniform tariff structure.** Already, the deaveraging or unbundling of tariffs, as is apparent in the US, is being discussed as a real possibility. If one were not to go this way, but retain the competitive options then one would have to tax the potential entrant at a rate which is sufficient to offsettany surplus losses which would be needed for cross-subsidization.***

*See also Section 8.

**Even now, tariff structures are not uniform as is apparent by the different population size of local exchange areas and the differenciated potential for calls it implies.

***For details see Müller 1982, for a somewhat similar idea, see Willig, 1979, p.26.

COMPETITION IN THE PROVISION OF TERMINAL EQUIPMENT

Conceptually, the introduction of competition in the terminal equipment market is much more straightforward. There are no significant economies of scale, and judging by the recent flood of entrants in the now liberated US market, barriers to entry seem to be relatively low. In West Germany, competition has already been practiced since 1902, since the Post Office and the equipment manufacturers both supply terminal equipment in competition with each other. This competition was said to be ruinous in the 1920s and 1930s and was then significantly restricted (Müller and Vogelsang, 1979, p.228). More recently, the experience in the US after the Carter one decision in 1968 is illuminating. The telephone companies (and their vertically integrated equipment companies) which had control over all terminal equipment and supplied nearly all of this, had now to compete with a newly established industry, the so-called "interconnect suppliers". Their share of the market is today 20 to 40%, mainly in the area of business application.* As a result, the innovative effect, and price/the performance/price ratio and the available product features have been significantly enhanced.

This policy was achieved with the Federal Communications Commission narrowing the boundaries of the legal monopoly for the telephone companies. The alternative would have been to regulate the emerging computer sector as well, as a distinction between communication and data processing was becoming increasingly blurred.

*For details, see Müller, 1981.

The many new applications, which are possible with today's telecommunications technology, make it almost impossible to have all the terminal equipment items provided by the PTT. Otherwise restrictions in consumer freedom and the choice of applications may be frequently heard. With an increasing application potential in the future, especially with respect to electronic mail, office of the future, and the increased use of non-voice communication, the pressure for liberalization will build up further. But even if one is convinced, as I am, that the terminal equipment market may be cut out from the legal monopoly area and assigned to the market sector of the economy, some regulatory framework must remain in force. This basically deals with the issue of compatibility, avoidance of harm to the network, etc. a task we turn to next.*

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*Thus the possibility of "privatizing" some sectors, i.e., to move it to increased competitive allocation may reduce some elements in the vector of regulatory rules, but requiring the strengthening of others. The issues of standards is here an important one.

A FRAMEWORK FOR COMPETITION IN THE TERMINAL EQUIPMENT MARKET

The Telecommunications Systems as a Whole

It has often been argued, especially in defense of the current legal monopoly set up, that the telecommunications system is made up of inseparable units, whose overall control has to be maintained in the hands of one central authority to ensure system integrity and service quality. This argument has been brought forward both by the privately regulated firms like AT & T and Bell Canada, and also by the European state-owned enterprises, like the BPO and the DBP.* Where competition in the terminal equipment market has been allowed to take place, it had to be under the rules of the responsible systems manager--the PTT. This traditional concept has recently become increasingly difficult to apply, however, given the emergence of new terminal devices. In addition, the PTT's have not always been fair in their rule as an arbitrator and judge of the competitive rules.

These arguments of technical inter-dependence are, of course, no reason to withdraw one sector from competitive allocation as such interdependence is also apparent in other economic activities. But it must be kept in mind, that to organize such a system efficiently an optimization in parts must lead to optimization of the system as a whole.

Regulatory rules designed to enhance competition ought to keep that in mind.

*See Müller and Vogelsang, 1979, pp.141, 225 for details.

Problems in Separating the Terminal Side from the Network

The major problems which make a unique separation so difficult rest on what we have called the "Federal Structure" of the telecommunication system is the same. In such a system, the customers have equally intensive communication patterns between each other. Separation between network and terminal parts is therefore fairly simple: the network would be seen as a sum of those parts of the system which are necessary for the transmission of signals between receiver and sender. The terminal side are all those parts necessary for coding at the senders' end and decoding at the recievers' end. We assume that this kind of definition could be maintained even in the face of continuing technical changes. Of course, the issue of compatability would always need to be kept in mind.*

Against this non-federalist model, reality is, of course, much more complicated. There, we find geographically unequally distributed participants, and, what seems much more important, different intensities of communication needs between participants. If we group these participants according to their main communicative interaction (basically like identifying a center of gravity) then we can identify, in effect, different sub-groups which have a different internal communication need. The larger the need for intra-group communications, and the more task specific and repetitive such communication needs are, the greater the tendency for a group to optimize its own communication needs. Therefore both the hardware and the software would be designed differently from that of the general public service system. This can either lead to the requirement for special types of terminal equipment, or even to specialized telephone networks, if the intra-group interaction is between geographically dispersed participants. Examples of such specialized terminal equipment are computer terminals in various forms like alarm signals, cash dispensers, point of sales, etc. Examples of specialized networks are that of the airlines, (SITA) or the networks of the banks (SWIFT). In such a system, the boundaries between network and the terminal side are now much more difficult to draw. For example, a PABX** would now be defined as part of the network, even though at the moment it is provided competitively in a number of national markets. On the other hand, specialized "closed networks" are even in Europe allowed to be set up on the basis of existing public networks.

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*For example, for each part of the system, no matter how peripheral it is, the question of compatability is foremost, strengthening the argument, that some regulatory agency, not the PTT should ensure such systems compatability. In any case, given these externalities, it is possible that even terminal equipment may have a network characteristic.

**Private automatic branch exchange.

The network becomes then only an information carrying device, no longer an open service (like Telex, for example). It is therefore important to note that, with a federal communication structure, a separation of the terminal equipment and network side is much more difficult, especially with an operating definition, which survives technical change and changing economic conditions. One may at times have to reinterpret these boundary lines.

At the same time the increased need for more specialized networks seems to indicate a special demand in addition to the public network concept. Here the economies of scale in network provision have to be weighed against the benefits accruing through specialization of sub-systems within a federal structure.

Criteria for Terminal Equipment Licensing

In spite of these difficulties, I would pragmatically argue for a set of regulatory rules which liberalize the licensing and use of terminal equipment as much as possible. As mentioned above, the technical advances in the telecommunications sector have been very substantial. The ability to translate them into productivity changes and a rising standard of living are important factors for the competitiveness of an economy. By allowing, to quote Hayek, 1945, the use of the competitive allocation process as a discovery procedure in the search for new applications of technology, the benefit of these new services may be extracted earlier as with an administrative system. This argues for increased liberalization of terminal equipment use, and, as we shall see later on, for network utilization as well.

With respect to the actual licensing criteria, there are a number of options possible. On one end of the spectrum lies the US criteria exemplified by the recent Equipment Registration Programme. It looks only at what has been called First and Third Party Harm. First Party Harm refers to safety consideration for the user, and Third Party Harm to safety consideration of network employees. Any equipment which does not cause First and Third Party Harm may be licensed.

Second Party Harm is not an argument against licensing in the US. By Second Party Harm we mean that the quality of transmission, because of poor terminal equipment is so bad, that the compatability is no longer insured. The Americans argue that this ought nevertheless be left to the market.*

*Some may even argue for the issue of First and Third Party Harm be left to the market as well. To settle this point, one ought to keep the relative high transaction cost of such a solution in mind.

This has enabled them to have a relatively simple licensing procedure. With only six or seven employees, they licence approximately 5-600 applications per year.* Turnaround time is below two months, compared to the much more lengthy certification process in Western Europe.

On the other extreme is the policy which is carried out in those countries in Europe where already some competition in terminal equipment is permitted. In essence, the PTT sets the rules and usually, in addition to requiring safety, (First and Third Party Harm) and compatability (Second Party Harm), also specifies additional product features. Quality competition, with respect to additional features or quality variations, is therefore extremely limited.**

My position is somewhere in the middle. I would require, in addition to the basic concept of the registration programme, the possibility to mandate compatability of the FCC, the avoidance of First and Third Party Harm. The basic argument is one of externality or Second Party benefit. This would at least require the establishment of some minimum quality characteristics.*** The other point is that sometimes a changeover to new technologies may require modifications, both in the network and the terminal equipment.**** By no longer licensing the out-dated equipment, the changeover to a new standard can be carried out faster.

I would, however, argue strongly against the specification of extra product characteristics, for example for reasons of system uniformity or the argument made by the Swiss that the interchange of telephone operators is facilitated by uniform product features. Some may argue that otherwise this would lead to increased product proliferation, perhaps even wasteful R & D, especially as compared with the traditional PTT approach, which emphasized standardized terminal products. I believe the market could settle this issue quite well, especially as some of the products mature.

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*See Müller, 1981, for details.

**Some European PTTs provide all terminal equipment directly to the customer. Competition therefore only takes place via the procurement policy of the PTT, which is often limited to a few national suppliers only.

***It is interesting to note that the Americans are quietly thinking about this aspect as well. But this will probably not result in a change in the FCC rules, but only in an attempt to self regulate a minimum standard by the Electronic Industry Association.

****For example a move from a three minute to a one-minute facsimile terminal.

In any case, the PTT is free to offer a range of standaridized products itself, which would help the customer to orient himself. Specialized needs of more innovative customers could nevertheless be fulfilled without any extre bureaucratic procudure.

Such a licensing policy would not take into account some other arguments which are currently popular with European PTT authorities, such as trade policy, employment policy or industry policy, and competition policy to mention only a few.*

What Role Should the PTT Play in such a "Liberalized" Terminal Equipment Market?

This is an argument which has aroused a particularly vehement discussion in West Germany. I will therefore just summarize the points made for and against the participation of the DBP. The same arguments apply probably equally well to the other West European PTTs. The arguments against participation:

-- the arguments for competition in a mixed economy require that a PTT as a state organization does not engage in a competitive sector, where services may be provided by the free market;**

-- network operators have a comparative advantage vis-a-vis new entrants into the terminal equipment market which gives them a competition advantage and leads to unequal competition;

-- the PTT may use its revenues from other activities to carry out predatory pricing; and

-- the PTT cannot be an objective judge for licensing criteria in the terminal equipment market if it participates in it at the same time.

The arguments for participation:

-- the PTT has an infra-structure responsibility;

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*For example, in West Germany and also in the UK the very advanced PABX by IBM 2750 (and later 3750) was initially not licensed, because the competitors were afraid to lose market shares. In cooperation with the PTT, they held off long enough until they were able to innovate themselves.

**In Germany this is justified on the basis of the "Subsidaritätsprinzip".

-- many customers have the desire to have network services and terminal equipment from one agency, simplifying dealings regarding service and maintenance problems. This possibility should be maintained;

-- the PTT requires experience from the terminal equipment market for its network policy ("window function");

-- the PTT as a state owned enterprise can increase competition in oligopolistic terminal equipment markets; and

-- the PTT must provide terminal equipment for such services which are not being provided by private suppliers.

These arguments center around three points: Economies of scope, predatory pricing and conflicting interest. By economies of scope, we mean the benefits which exist by supplying more than one service through the same firm (see also Panzar, Willig, 1975). If economies of scope exist for network operators with respect to the distribution and servicing of terminal equipment, then the PTT ought to be allowed to exploit these benefits. Some of the arguments mentioned above go in this direction, and we would therefore accept them. But since it is not clear in which markets economies of scope are important, one should leave it up to the market to discover the extent of these benefits.

On the other hand, economies of scope may also play a role in the PTT as a licensing body for the terminal equipment. In this case, however, we have to weigh these benefits against the potential for abuse of this position because of conflict of interest.* It seems quite clear from the way the Americans have carried out their registration program, that economies of scope are not very important. The licensing function can easily be delegated to a separate independent authority, to avoid the conflict of interest problem.

An important issue which has come up in this debate, and which has not satisfactorily been resolved, is the issue of predatory pricing, which is, of course, another form of cross-subsidization. Especially if a commoncarrier is active in other markets, in which economies of scale are large, and the threat of entry is low, a subsidization of entry threatened activities may prevent such entrance from taking place. The US proposals ahve included the setting up of separate indepedent arms-length subsidiaries and the requirement for refined accounting methods to better control the potential for predatory pricing.

*The PTT cannot really be a player in the market and a referee at the same time.

However, even though existing accounting methods could be greatly improved (see MKW for details) the persistence of economies of scope could really make the setting up of arm-length subsidiaries an economically inefficient exercise.

The issue of predatory pricing is complicated by the complementary relationship between network and terminal equipment. In Germany, the Post Office was accused of predatory pricing regarding its recent introduction of "Telefax" (facsimile services) because it used unusually short term leases. On the other hand, the PTT as a network operation must be interested in securing the quick growth of new services, whose appeal increases with a larger network of customers. By adapting such a policy of short term leases, it encouraged the willingness of some customers to experiment with new services.*

As a basis of the above discussion, we would therefore argue for a participation of the PTT in the terminal equipment market. There are three important considerations to be borne in mind, however. First of all the danger of predatory pricing has to be checked via a more cost-oriented accounting method. Secondly, the licensing function has to be kept separate from the PTT. Thirdly, the authority of the anti-trust institutions should be extended to cover the PTT activities as well. In the case of Germany, this would mean an extension of the abuse of dominant market power law (paragraph 22 GWB) to such activities.

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*The other problem which seems much more serious is the difficulty of the PTT to attribute its costs adequately to each service. For this reason alone, the problem of even unintentional predatory pricing remains. It is therefore also much more difficult for the market to determine the economies of scope advantages a PTT inherently has.

A PROPOSAL FOR UNRESTRICTED NETWORK USE

We have already argued for a policy to ensure a maximum amount of liberalization, both in the use of terminal equipment and the existing networks. This should also include the possibility of resale to third parties eventually leading to Value Added Networks. Such a policy would certainly allow the network to be used more rationally and would allow innovative entrepreneurs to discover new utilization policies for the telecommunications network.

The drawback of such a resale policy with respect to network use is the danger of cream-skimming. Value added networks or other entrepreneurs will tend to re-sell a given network capacity to third parties, when tariffs are not proportional to cost. If the tariffs are cost-oriented, then third parties will only find it beneficial to re-sell existing network services if they are more efficient in that than the existing PTT or provide additional value in the form of data processing, message storing and forwarding or packet switching, for example. Both tendencies are then desirable.

Nevertheless, some governments may still insist on a unitary tariff policy in order to encourage cross-subsidization to less densely populated regions. In this case, a tax would have to be levied on such third part sales which would be equivalent to the amount of cross-subsidizing revenue lost. Only if a third party retailer was more efficient, or created some value added (for which his own costs were below revenues) would he be able to enter.

Unrestricted network use would therefore lead directly to a cost-oriented tariff structure. This argument is therefore also made on the basis of giving the price signal a more important function in the telecommunications sector. Often we observe co-existing networks next to each other (for example data and telex networks) which may serve similar functions, but are priced differently for policy reasons. There is no technical reason why such differentiation takes place. A policy of more liberal network use and a more cost-oriented tariff would take innovative developments directly to consumers, and allow them, if necessary, to optimize their system from their point of view. In addition, such a move would as we have mentioned above, depoliticize tariffs, at least between different services.

The question left open is to what extent such competition will put enough pressure on the PTT to also behave more efficiently in its network configuration, (i.e., without proposing already now network competition). If PTT's engage in gold-plating, then, at least at the moment, we do not really see the competitive pressure of value added networks with respect to the network configuration of the PTT. This will only be possible if one allows either genuine network competition, or at least intermodal competition between terestrial and staellite services, for example via the use of international satellite. If this option is not feasible, regulatory pressure on the PTT must remain high to provide for efficient network configuration.

CONSEQUENCES OF A LIBERAL TERMINAL EQUIPMENT AND NETWORK UTILIZATION POLICY

If the terminal equipment policy, which we recommend, is implemented, then a much wider range of terminal equipment products will be available as compared to now. This will not only increase the available product spectrum to customers in the short run, but also increase competition and innovation in the long run. One can certainly conclude this from the policy in the United States, even though the market before the Carter one decision had a much less competitive structure as compared to the European one. The economic lifetime of the equipment will probably decrease and reflect technical change much more than at the moment. I do not believe that such policies would lead to equipment proliferation as has sometimes been argued. But even with the implementation of such a proposal, I believe that the PTT will continue to play a strong role in the terminal equipment market, especially with respect to household customers. Business users will probably be more easily competed away by direct suppliers, as they have more specialized needs. At the moment, in the U.S.A., the terminal equipment market, which used to be 100% common carriers is today 40% controlled by so-called "interconnect suppliers". (See Müller, 1981.)

Regarding network utilization, a resale and shared use provision will result in a more effective utilization of the network. The existence of value added networks should help the PTTs to bring their tariff policy more in line with existing costs. A more innovative utilization could be the direct result of such a policy, even if the PTT by itself does not move in this direction. The VAN may lead such developments. In addition, if individual firms are allowed to both use terminal equipment and networks according to their own discretion, many more innovative potentials will be realized than are currently possible with the very slow bureaucratic opening-up of new services by the PTT. This will not always lead to a universal service structure, but with the emergence and need for more specialized networks, such a policy ought to be encouraged.*

*Already now, the PTT's are having a difficult time policing the activities on certain leased lines.

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DEBITS AND CREDITS IN TELECOMMUNICATIONS*

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1. Introduction

Under the term "telecommunications" we understand all means of remote information transfer between two subjects (man-man, man-machine, machine-machine) or among groups of subjects (machine-people, man-people, machine-machines, and all combinations thereof). We emphasize the necessary adjective "remote" because direct communication and local communication, which are governed by other rules, are beyond the scope of this paper. We shall not touch upon the notion of information and its value, in spite of the fact that these play an important role in telecommunications, particularly in benefit analysis (see Braun 1982). We shall adhere to the vague definition of telecommunications as all information that is transferred by means of electrical signals, regardless whether it is helpful to the user or only confuses him.

For the most part, because of their wide political, economic, and social impact on the government, industry, defense, business, and life in general, the telecommunication systems and networks are owned by the PTTs, which are governmental (rarely private) branches. For the sake of clarity, the telecommunication system owner will be called a vendor throughout the paper. By this is meant a PTT, a recognized private operating agency (RPOA), or other responsible for telecommunication networks installation and maintenance.

From the point of view of the vendor all users are subscribers. At present, however, subscribers do not utilize telecommunication systems for passive information transfer alone; they also take advantage of some information services and resources and become information consumers. We will adhere to the general term user. The third subject, the manufacturer (supplier) of innovative facilities, oscillates between the vendor and the user.

The aim of the paper is to elaborate on ideas and issues formulated concisely and exhaustively by Vasko (1982), particularly on his section concerned with selection environment and relations to other sectors with respect to the efficiency.

2. The Benefits of Telecommunications

Telecommunications, whose origin dates to the last century (with the invention of telegraph and telephone sets as well as the first radio transmission), very soon became the largest technological system. The worldwide telephone and telex networks, the national broadcasting and

*I would like to express my gratitude to Tibor Vasko for his encouragement, useful suggestions, and advice. I am also grateful to IIASA for making possible the visit to the Institute during which I wrote this paper.

television systems, and the regional radio mobile systems have all been accepted as inseparable from governmental, industrial, business, and human life.

In spite of the fact that telecommunications is a capital-intensive branch with substantial operating costs, in the past it has been expressed in vague political and sociological terms. This is not surprising in cases where the main expenditures are supported by the government (the PTT as a vendor is state-operated in most countries), which rarely (or never) has asked for revenues.

The situation has changed recently due to limitations on resources, i.e., energy. Now each innovation in telecommunication, each introduction of a new service, each improvement in telecommunications performance, is being accompanied by the very simple question: "*How much will it cost and what profits will it bring?*" While the question is simple, the answer would be practically unobtainable if we were to rely on traditional approaches to calculating benefit.

The man with a telephone on his table rarely calculates how it saves his time and/or money if he used it instead of physically going to the party with whom he wished to communicate. Nor does the family with a TV set save money in the family budget by watching a TV performance rather than going to the theater. These and many other examples show that information transfer can replace mass transport. This idea is not new (see, e.g., Day 1978; regarding data communications, this is dealt with in detail by Maurer et al. 1982). Thus the benefit of every telecommunication system or network can be calculated in terms of energy conservation.

Although telecommunications has been conservative in its evolution due to barriers tied with international standardization (needed to facilitate collaboration between countries), from time to time it needs to be innovated. While the innovation cycle in the telecommunications industry is five years or less, the rate of return for telecommunications equipment is placed at 20 years and the real lifetime is known to be twice or three times this (for example, for cables and exchanges). Nevertheless, manufacturers are eager to sell their up-to-date (and more expensive) telecommunications equipment, so they try to prove the necessity to implement it into existing networks.

It has been claimed that the forthcoming telecommunications facilities will be less energy demanding than the present ones (see, for example, Maurer et al. 1982). This is true as far as transmission equipment is concerned, but the electrical energy saved is too negligible to be used to support an argument. It may be true of broadcasting (to a greater extent) and TV transmitters (to a lesser extent), but in the sum, the savings are not very significant. It is completely false, however, if we consider one of the most scattered and therefore energy-consuming telecommunications facilities: the exchange. While by using earlier types of exchanges based on relays or the crossbar, one can conserve much electricity during operation time, the modern switching systems (semielectronic and electronic) are on the average highly electricity-consuming. But they smooth out the consumption peaks, and this represents progress, since such exchanges economize energy during peak hours, allowing it to be saved up at power plants.

There are, however, other reasons why innovation is needed in telecommunications. Besides space, and therefore building capacity and manpower savings, innovation makes possible new services with higher performance, which in turn are transformable into energy saving.

Consider such services as data communication, cable television (CATV), teletex, teletext, videotex (viewdata), videotext, bureaufax, telefax (remote printing), teleconferencing, and videoconferencing, each of which represents an almost identical service, although they are called differently from one country to the next. Although most of them are in commercial operation and are already tied with CCITT recommendations we cannot be sure whether all will survive, or whether they will share the fate of the short-lived American videotelephone (Picturephone). Careful calculations and assessment, however, presage their mass development, particularly in view of their potential for saving energy (Kraemer 1982).

New techniques and technologies are already greatly affecting telecommunication performance. Since telecommunications has many dimensions, its quality is expressed in terms of the values of performance parameters used to evaluate user demand criteria rather than by some figure of merit. Table 1 shows the criteria and some of their parameters.

Table 1. Telecommunications performance.

Performance criterion	Performance parameters
capacity	bandwidth, transmission rate, throughput
readiness	access time, delay
fidelity, accuracy	intelligibility, S/N ratio, error rate
reliability	MTBF, MTTR, availability
source/sink layout	distance, transmission power, receiving sensitivity

A typical parameter that tends to improve is transmission rate and bit error rate. Through new technology the transmission capacity has increased from several bits per second in the last century to several hundred megabits per second today, resulting in a corresponding increase in transmission rate. And only within the last 15 years, new technology has decreased the bit error rate of data communication services by the same order. (see Table 2).

Table 2. The trend toward higher accuracy as reflected in bit error rates.

Type of Service	BER (bit error rate)
Switched telegraph and telephone lines	10^{-4}
Leased telegraph and telephone lines	10^{-5}
Message-switched network	10^{-8}
Public line-switched network	10^{-9}
Packet-switched network	10^{-12}
Public packet-switched network	10^{-15}

There are, however, certain weaknesses inherent in new telecommunications technology. The satellite technique causes greater and moreover fluctuating transmission delays than with common wire and radio (240-270 milliseconds depending on the layout of the terrestrial stations in relation to the geostationary satellite), which, on the other hand, enables the sending station to "hear itself". The store-and-forward technique prevents users from conversing (in man-machine dialogue) and the users are subject to a lack of audience (in teleconferencing). Finally, modern technology must combat information misapplication and wilful annihilation, problems that have arisen because modern telecommunications techniques do not afford the privacy of mail and tete-a-tete conversation.

As an example, let us show how modern technology worsens the call set-up time in circuit-switched networks. Table 3 shows the typical values of call set-up times for four generations of switching technologies for connections within an exchange and connections via three exchanges. In defiance of very high speed LSI and VLSI technology, electronic switching systems call for decentralized control and for control data exchange between stations when setting up a call by means of several exchanges and this consumes quite a lot of time.

Table 3. Set-up times of switching systems in circuit-switched networks.

Switching system	Set-up time (in milliseconds)	
	within 1 exchange	via 3 exchanges
Step-by-step (1st generation)	220	220
Crossbar (2nd generation)	1700	2300
Semi-electronic and electronic (3rd and 4th generations)	80	700

But regardless of the pros and cons of implementing new technology into telecommunication systems and networks, we may conclude that innovation in telecommunications affords benefits that are quantifiable in terms of energy, time, and cost savings.

Now we turn our attention to another side of coin: expenditures.

3. The Costs of Telecommunications

Although all telecommunication networks (telex, telephone, broadcasting, TV) are large and sophisticated, the charges for their services are disproportionately low everywhere. For example, a telephone call between two users involves the complexity of setting up the connection and the high requirements for voice transmission capability, which must sometimes smooth out traffic peaks and compete with noise and other disturbances. And yet the charges for such a call can generally be quoted in mere fractions of the local currency. The user's budget is scarcely burdened by telecommunication expenses.

The vendor, however, must invest in the telecommunication equipment, maintain it and innovate it. Both capital expenditures and operating costs are enormous and these can hardly be returned in a short time. This explains the long rates of return in telecommunications. Moreover, the price of innovative equipment continues to rise regardless of its ability to benefit the vendor directly (as in absolute manpower saving).

The vendor has in fact a tool for improving his position: tariffs. Upon introducing a new service he sets the tariff, which should pay for his expenditures as soon as possible, at an appropriate level. However, if the tariffs are too high they will cause the user to utilize the new service less or prevent him from utilizing it at all. For example, greatly increasing the installation charges for telephone subscriber lines will result in a decrease in the number of potential users.

There is, however, another solution. By introducing new telecommunications systems not based strictly on vendor's facilities (the data transmission and computer networks have been such cases) and requiring the user to purchase and maintain a part of the communications equipment, the vendor shifts some capital and operating costs to the user. The installation and operation of the user facility, which is closely connected to the vendor's property, is supervised and controlled by the vendor. In Czechoslovakia at present all telegraph devices and PABXs are purchased by users. However, they become the property of the PTT, which must maintain them. This policy decreases the capital expenditures of the vendor.

We very often meet with this type of situation with respect to new telecommunications services. In computer networks the whole environment demarcated by DTEs (terminals, HOSTs, FEPs, communication controllers) belongs to the user; the same is true of videotex, teletex, CATV, etc.

We have mentioned CATV (cable television), which is very costly. Let us point out its negative impact on the user's budget. Suppose CATV does not replace direct TV reception, but only enables good reception in "hidden" areas (those covered insufficiently by TV signals). As CATV must be installed and maintained by the user, inhabitants then fall into two groups: those who have good reception and need only pay for a cheap antenna, and those who have to pay several times more for the CATV.

Finally, it should be noted that new services also charge users according to transport and travel expenses (this expanding cost is surprisingly high due to the need to set up terminal equipment at remote locations) and by learning expenses (the user must become skilled in handling the new terminal equipment, and he must become familiar with the types of services it offers and get accustomed to its features).

Now let us turn our attention to telecommunications tariffs. If we examine the national tariffs currently in effect in Europe, we can see very great differences, even between neighboring countries. Both the level of tariffs and their structure vary widely from one country to the next. As an example let us take the monthly rental charges for inland leased telephone lines as a function of distance (see EURODATA 1981). Figure 1 shows several typical functions: purely linear, linear with a point of saturation, piecewise linear, and stepwise. We most often encounter the stepwise rate outlined in Figure 1. A closer analysis shows that the number of steps ranges from three in tiny Luxembourg, where only three rate zones (within the same telephone exchange, between exchanges within a sector, and otherwise) are distinguished up to 15-17 in the Northern European countries (Denmark, Norway, Sweden). Some linear functions in fact approximate the stepwise form having uniform steps of one hundred meters or one kilometer, or irregular steps as in the United Kingdom. Note that beyond a certain distance, rental charges in Belgium, France, Ireland, and the UK become distance independent while in other countries they remain distance-dependent throughout the range of the country. For stepwise dependency, however, the saturation level is always determined.

Although different countries have different tariffs the performance of services is nearly the same due to international standardization (CCITT recommendations).

Similar differences can be found in international charges. Thus it is not surprising that companies have begun to shop around for the best locations to set up centers for their computer networks. For example, IBM chose the UK for its Response Time Sharing Service (Lloyd and Peltu 1981). The charges for accessing the US packet-switched networks of Tymnet and Telenet for Europe vary by a factor of 40 depending on which vendor (PTT) hosts the user terminal (Sebestyen 1980).

Such discrepancies should be eliminated and a uniform tariff policy should be agreed upon.

4. The Cost-Benefit Balance

When expressing the economic efficiency of any device or system, regardless of what formula is used the values of benefits and costs must be known. Generally speaking, the efficiency is the relation between attained useful benefit and consumption of social work and is most often expressed in financial terms (see Table 4). Note that in Table 4 operating expenditures are not explicitly expressed in C and are hidden in B. (Each benefit must be diminished by operating costs.) However, this does not change the essence of the matter. Without exact calculations of the amount of benefits and cost, no economic efficiency measurement can be specified, despite the fact that the formulae in Table 4 seem to be very

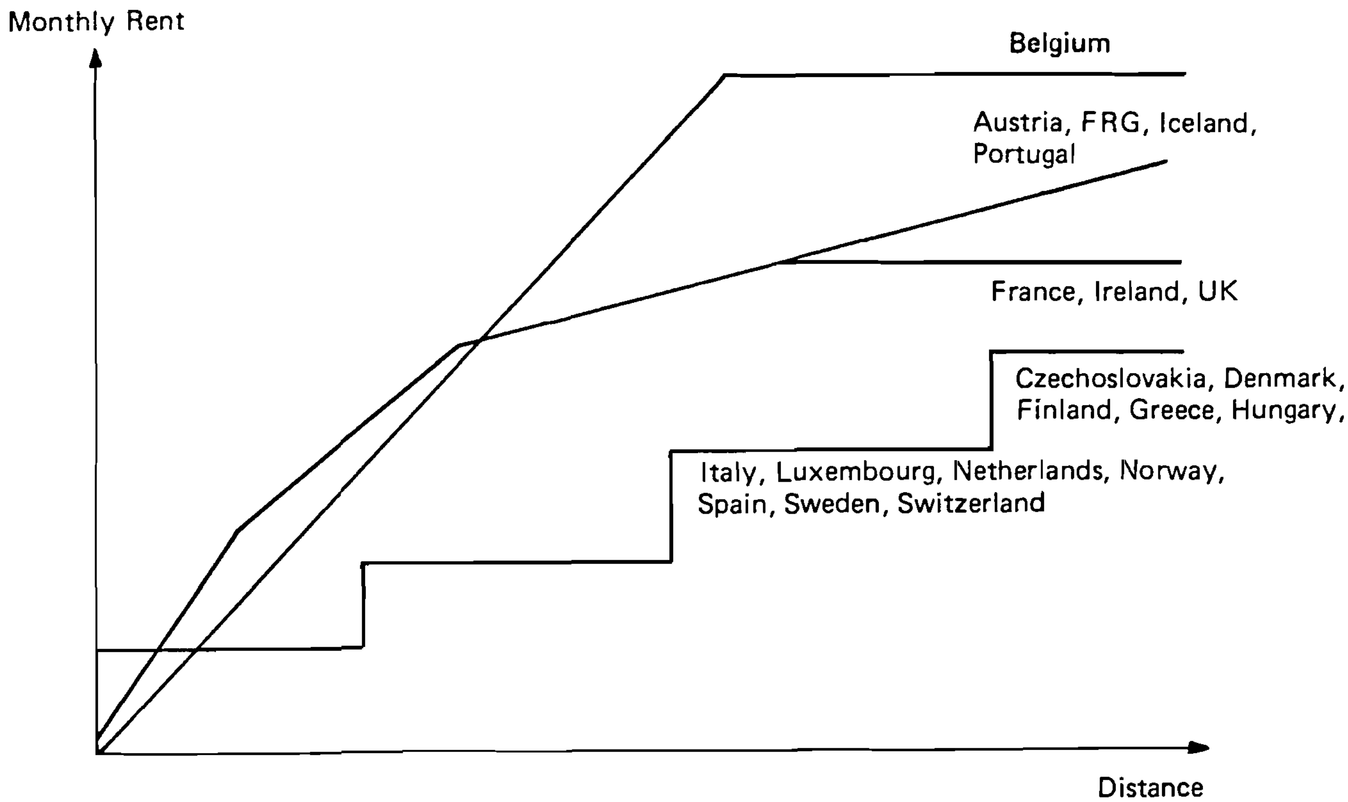

Figure 1. Types of monthly rentai tariffs with dependencies upon line distance.

simple. (Of course they do not respect the time value of money.) There remains the question of how to achieve an appropriate income, because the optimization problem is, in general, insolvable.

Table 4. Measurements of economic efficiency.

Total benefits	B
Total capital costs	C
Lifetime	T
Total efficiency rate	$E = B/C$
Efficiency total rate	$B - C$
Time of refund	T/E
Return of investment	E/T
Costs/benefits balance	$C/B = 1/E$

First of all, let us look at the relationship *vendor-user-manufacturer*. Originally, there was a strong link only between vendor and manufacturer, who influenced each other while the user was a passive consumer of telecommunications services (see Part a) of Figure 2). While this alliance still remains, the user is moving closer to the vendor and at the same time is building up a relationship with the manufacturer, whom he looks to supply and maintain a part of the telecommunications system (Figure 2, Part b). Thus a triangle or "three-sided coin" has arisen, in which each partner seeks to be as efficient as possible.

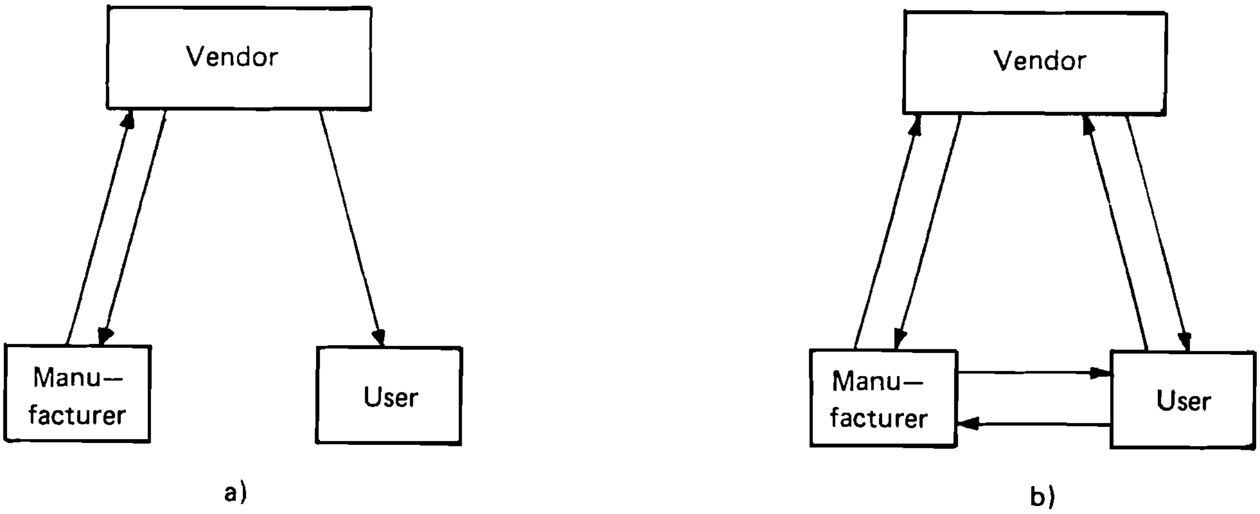

Figure 2. The relationship vendor-manufacturer-user.
a) previous b) present

The behavior of the manufacturer is governed by common economic laws, just as in other branches. However, the telecommunication manufacturer is not only bound by certain constraints such as those imposed by the national standardization body, but also by restrictions which may be more robust than in other branches. The supply need not be accepted due to unsatisfied technical demands from the vendor side regardless of a discount and may not be marketable at all due to the vendor's monopoly. Thus we should pay particular attention to the relationship between vendor and user.

The two subjects stem from the telecommunications system performance (which we denote P bearing in mind that it is a multicomponent vector of performance parameters), which indicates user benefit, and the telecommunications costs (C) expressed for our case both in the capital and operating expenditures of the vendor and in charges to the user for services. The charges, based on the vendor's tariff policy, should balance the vendor's expenditures.

When a vendor invests money to install a technology, he seeks to provide the best services with the highest performance values. The user, on the other hand, wants to meet his demands at minimal costs. So we can write:

from the vendor side :

max P for C being constant or limited by some C^*

from the user side :

min C for P being constant or limited by some P^*

where max and min are taken over all services afforded.

Let us show this using a simple example. The user wishes to connect a keyboard terminal to a computer. The lowest sufficient transmission rate is 200 bits/s. The vendor provides two types of services: either he will lease telegraph lines at lower charges or he will lease telephone lines at higher charges. The user, who has access to all the necessary data, decides which type of service would be more convenient for him. Although the telephone line allows a higher transmission rate (up to 10 kbits/s) the user opts for the telegraph line in order to minimize costs.

Once he has established a telephone line, the vendor has an interest in leasing it. If the line is too expensive for a single user, he can equip it with an exchange or a multiplexor (MUX) and offer it to several users at a suitable charge in order to induce users to prefer it to the telegraph service.

These efforts are closely connected with vendor tariff policy assessment. This is not just a question of absolute charge figures but rather of their dependency upon performance parameters.

Charges for lines depend primarily upon transmission rate or bandwidth. For example, leasing charges for telegraph circuits and telephone lines increase with increasing transmission rate, regardless of whether the cost of the data sets, which are owned by the user, also increases.

For the sake of simplicity, let us imagine a linear dependency (see Figure 3). The vendor leases the line with a certain range of transmission rates R. The charge C may be either transmission-rate independent or linearly dependent. Two parameters influence the behavior of users and vendors: c_0 and k.

If $k = 0$ and $c_0 > 0$, this is advantageous for the user because he need not take care of the efficiency, but it is inconvenient for the vendor as he must invest much money establishing and maintaining the line up to the highest transmission rate. However, he is able to ease his expenses by an appropriate choice of c_0. If c_0 is high the user tends toward higher utilization of transmission capacity since the relative costs for, let us say, each kbit transferred is cut down.

If $k > 0$ and $c_0 = 0$, this is ideal for the vendor if k is appropriately chosen (say $k = 1$). On the other hand, however, the user would prefer to lease more lines when he needs more capacity (for example, a doubled rate would lead to the leasing of two lines, which would take up a large part of the telecommunications network capacity).

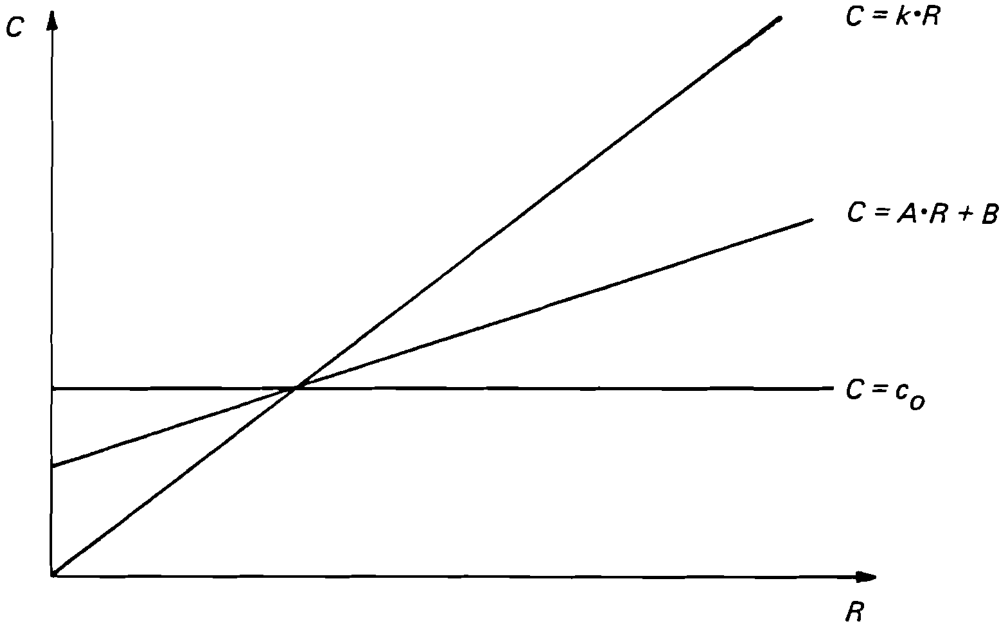

Figure 3. Line charges with dependencies upon transmission rates.

So there must be a compromise. In the simplest case, this acquires the form

$$C=A\cdot R+B$$

where A and B are positive constants.

If we look at the tariff policy in different countries (see Table 5), we find out that almost all follow this compromise, except in the case of very small distances.

Table 5. Relative charges for telegraph circuit leasing.

Country	Transmission rate R [bits/s] 50	75/100	200
Austria	1	1 ÷ 1.25	1 ÷ 1.625
Belgium	1	1.2	1.4
Czechoslovakia	1	1.2	1.6
Ireland	1	1.2	1.8
Netherlands	1	1.25	1.5
Sweden	1	1.2	1.6

The second example deals with another situation. The user seeks to minimize costs by consolidating the traffic of his terminals and so he asks for a single line. The vendor, aware of the user's scheme, leases the line for an additional charge.

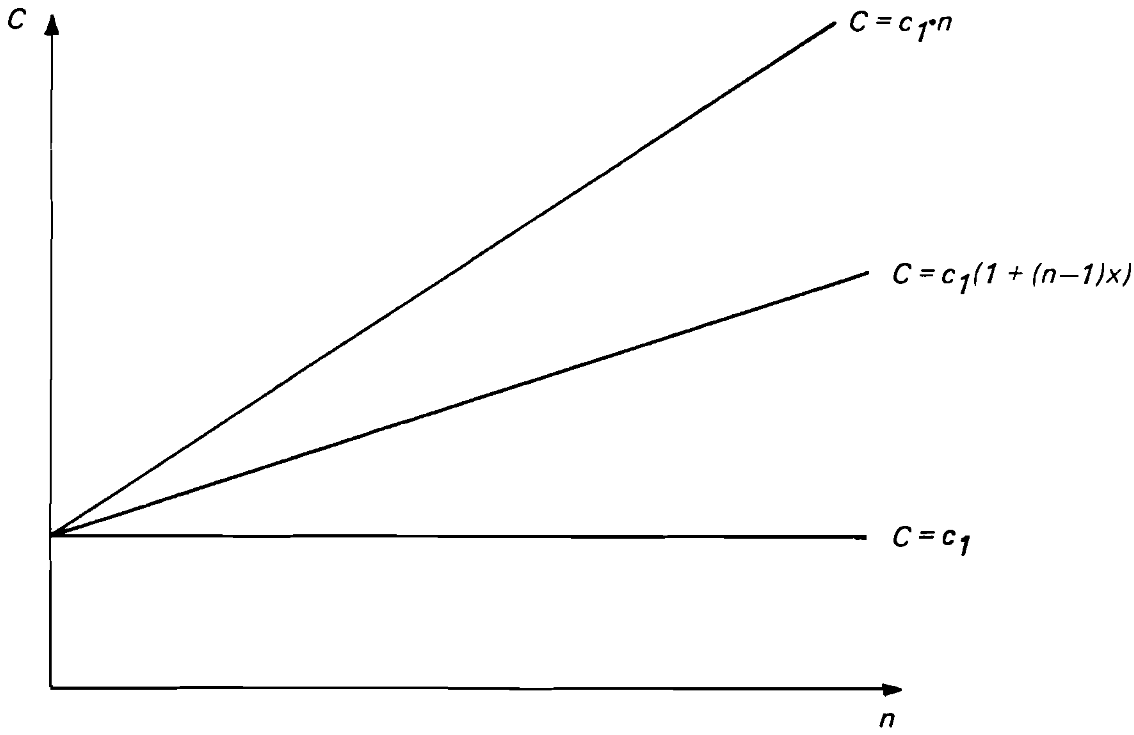

Figure 4. Line charges with dependencies upon number of users.

How can the tariff be set so as to satisfy both the user and the vendor? We shall again recognize two extreme cases: either the total charge does not depend upon the number of additional users or it is purely linear (see Figure 4). The general dependency should be placed between the two outside extremes. Suppose again that the dependency is also linear:

$$C=[c_1 1+(n-1)\cdot x]$$

where n stands for the number of users and c_1 is an initial charge. If $0 \le x \le 1$, the parameter x determines the region of our interest (for $x = 0$, the charge is constant; for $x = 1$ it is purely linearly dependent). It should be defined in such a way as to take into consideration the additional user's costs γ for the sharing unit (MUX static or dynamic, concentrator, terminal controller, etc.) and if need be, for other complex arrangements (multidrop, direct access, packet switching, etc.) Thus the total cost is

$$C=c_1[1+(n-1)\cdot x]+\gamma=c_1[1+(n-1)\cdot x]+\gamma_1(n-1)$$

where γ_1 is the relative cost for a sharing unit related to each additional user (for $n = 1$, $C = c_1$), because the line is not shared).

The user wants to have

$$C < n \cdot c_1 .$$

From this it follows that

$$x < 1 - \frac{\gamma_1}{c_1} \quad (if \quad n > 1),$$

which must be positive. The condition is fulfilled if $\gamma_1 < c_1$. For example, if we choose $x = \frac{3}{8}$ then γ_1 should be smaller than $0.625 c_1$. Otherwise sharing the line capacity would be disadvantageous to the user. Thus the tariff function depends on the costs of the sharing units and becomes dependent on the manufacturer.

A brief look at the tariffs shows that in some cases there is a fixed additional charge regardless of the number of users, as if $n > 1$ (Czechoslovakia). In others, the additional charge depends upon whether $n = 2$ or > 2 (Belgium) or upon the type of users (as in Switzerland where the users in different trades are distinguished). No tariffs take into account the prices of MUXs and other sharing devices on the market. The role of manufacturers should be to adjust their cost policies to fit those of the vendors. Thus we come back to the original "three-sided coin".

5. Conclusion

The brief remarks on telecommunications costs and benefits given above cannot lead to any general conclusions or recommendations. However, it is possible to make some partial judgments, which in our opinion will help in investigating the problem more thoroughly.

It is clear that innovation in telecommunications is needed; its benefits are beyond dispute. On the other hand, technological progress is more rapid in the telecommunications industry (on the manufacturers' side) than in operating telecommunications systems and networks (the vendors' side). Not every innovative telecommunication technique and device, no matter how sophisticated its level, is immediately implemented into the network. This is a fact that must be reckoned with.

However, there are barriers other than technical ones that prevent innovation in telecommunications networks. We have mentioned only one: the tariff policy and its lack of harmony even within the European range. This problem is beginning to be solved; it has been included among six priority areas of CEPT efforts (Benedetti 1981).

Smoothing out tariffs is necessary but it is not enough. New services call for a new approach to charge allocation. The present more or less complex tariff structures (for details see EURODATA 1981) do not comply with even such already "ancient" services as data communications, not to mention the new services described in Section 2. One tariff model for data communications services was proposed by Ratz an Field (1980).

This is one way to start tearing down the "Chinese walls" that are separating telecommunications vendors, manufacturers, and users, and impeding more rapid progress.

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CONFLICTS BETWEEN TELECOMMUNICATIONS POLICY AND INNOVATION IN INFORMATION

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1. Status

This paper is not a report on work carried out in this area: instead, it should be regarded as an initial look at an interdisciplinary area for analysis, in which two sets of forces intersect, and the result of this intersection will largely determine the path and pace of future developments in both.

The two forces which will concern us are those which channel the development of telecommunications services (telecommunications policy), and those which are responsible for the increasing pace of innovation in information provision, handling and distribution generally. Policy issues in both areas have a large technological content but also involve important elements of social and financial concern. In respect of the latter, for example, both are big business: we have already seen indications of the scale of investment by the PTTs in telecommunications, and according to a study commissioned by the UK Government reported in the Financial Times of 27th August 1981, the world market in information technology amounts to £50 billion. An understanding of the conflicting pressures and interactions between these two forces is therefore not unimportant from the general public policy point of view. What follows could be regarded as background material for discussion, the object of which might be to define a hypothetical study program in this area.

2. The Telecommunications Services Industry

One starting point might be to try to identify the particular characteristics of the telecommunications services industry which have a determining effect on telecommunications policy. By "telecommunications services industry" is meant those organizations which provide or assist in providing telecommunications services: this will include government ministries, state owned agencies, private companies having either a monopoly or a limited franchise to supply telecommunications services, and in some sense, equipment manufacturing companies having a "sole-supplier" relationship with a telecommunications administration, agency or carrier. (The influence of sole-supplier arrangements as a possible factor narrowing the technological basis for innovation in market economies is an interesting topic for speculation).

The influence of the monopolistic character of the telecommunications services industry on the manner in which telecommunications policy is made, and its actual content, is clearly central to any project of this nature. Differences and similarities between the three basic types of monopoly in their effects on policy formulation and its content may also be important. The following three classes of monopoly should perhaps be considered:

- Government ministries (directly reporting to the council of ministers or cabinet on policy)
- Government agencies (with possibly limited independence in certain matters, precisely defined by their statutes)
- Private companies with extensive or limited franchises regulated by a government agency or ministry, the terms of the franchise being subject to continuous review.

3. Specific Aspects of Telecommunications Policy to be Examined and Compared

The following is a list of *some* of the points which need to be considered in this part of the analysis:

Defense of Monopoly Powers.

The terms of the monopoly are usually rather broad, and while subject to a legal text, may require interpretation. For example, up to quite recently there were problems with so-called message switching in Western Europe, i.e., using a terminal attached to one host to send messages to a terminal attached to another host via a computer network. This is in fact a theoretical infringement of the monopoly, but if it is allowed at all, the terms under which this may be done are laid down by the PTT concerned, but do not form part of the broad-based legislation. The PTT is thus a judge in its own case: the same sort of problem may well be resolved differently by other types of monopoly. In Western Europe at least, the PTTs -- and their international consultative body, the CEPT, are still very quick to produce a new ruling by way of interpretation of their monopoly powers when they feel them threatened by some new development. However, there seems a tendency to turn a temporarily blind eye on possible infringements when these produce new, semi-experimental service elements which the PTTs are not yet ready to provide. Probably one of the most noteworthy examples of this was the manner in which the original nodes of the TYMNET network were allowed to operate in France, Switzerland, and UK as privately owned termination points of an American network outside European PTT control.

Actions in Support of Social Policy Aspects

The monopolistic nature of the telecommunications services industry carries with it the obligation to consider questions of the common good (however that may be defined) in addition to matters of commercial viability in making services available to the public. A particular example of this is in "rate averaging" practiced by the large majority of telephone services everywhere. In this, while it is recognized that the unit *cost* of providing telephone services in remote or underinhabited locations is very different from that of providing services in urban areas, the unit *prices* should be roughly averaged so that the isolated rural user does not have to pay the full cost of the service he receives, being subsidized by higher rates applied to the urban user. In fact, the same tactics of cross-subsidy are often applied on a broader scale, *between* services: for example profits resulting from high prices to telecommunications users are used to subsidize the loss-making postal services, etc. By syphoning-off funds for investment such practices can affect the rate of innovation.

Standardization Policies

It is obviously necessary in a continent like Europe that a policy of technical standardization is applied. However, each Administration is a sovereign body, and standardization takes much time and effort: although this piece of international machinery has been remarkably effective it can have two types of effect on technological and service innovation: first, in certain respects (facsimile equipment is an example) too early standardization freezes the technology at a level below the best available; second, standardization requires much time, and therefore tends to delay entry of new systems and services to the market.

Accounting and Write- Off Policies

Kimbel (1973) underlined the effect of accounting policies by European PTTs on the rate of innovation and new equipment design. It turned out that, (in 1973) that many PTTs in Western Europe had been following the practice for many years of writing-off equipment at a rate which resulted in a zero figure in the books at the end of 20 years. Replacement of equipment, and therefore the entire research and development and design cycle had been geared to this write-off policy. This may be contrasted with the much more rapid research and development and design cycle in electronics, particularly the computer industry, and the write-off policy associated with it in which zero book-value is reached in five to seven years. Kimbel points out the consequences of this in the relatively slow rate of introduction of electronic exchanges and computer controlled load-sharing in Western Europe as compared with the USA in the late 60s and early 70s.

4. Structure and Characteristics of Institutions in Information Technology

The hypothetical study program would involve looking at the institutions and organizations which constitute the innovative driving force in information technology from the point of view of the way they act structurally and operationally with the telecommunications services industry. At the production level there is probably very considerable overlap between the two, but on a institutional level and from the research and development side, there appear to be great dissimilarities.

These dissimilarities are striking in the case of the computer industry, one of the major innovative components in information technology. In place of monopoly there is fierce competition. The industry is strongly marketing and sales-oriented, while in the telecommunications services industry, the administrations have only recently begun to think in terms of marketing and sales campaigns. The PTTs have a history of good quality research and development going back many decades, but a comparison of strategies and financing for research and development as between the telecommunications services industries and the computer industry should be interesting as a contribution to comparing the innovative process in both.

A point requiring study is the non-homogeneity of the institutions, firms, and organizations concerned in information technology. Unlike the rather monolithic structure in telecommunications, information technology includes at one end of the spectrum giants such as IBM and at the other very small enterprises based on high technology, but also strongly entrepreneurial in character.

However, within the last few years, there have been indications of some degree of convergence in these respects: the development of videotex systems by certain telecommunications administrations seems to have had some of the characteristics of innovation typified by the computer industry (research and development hand in hand with an innovative marketing strategy, entrepreneurial motivation, etc.). Other examples of such convergences in the approach of management might be sought for and examined in depth.

5. Interactions and Conflicts

In one sense, the telecommunications services industry and the organizations, etc., concerned with information technology have always been closely linked since information transfer is the main purpose of telecommunications: however, information technology is also concerned with other media for information transfer, and the basic relations between the two would repay further review.

A different type of interaction began to be apparent when telecommunications and computers began to be physically linked in what is now sometimes called teleinformatics, and at this point conflicts of interest emerged. The following are merely pointers to areas which would repay study to increase our understanding of the process:

The "Foreign Attachments" Battle

The hierarchical nature of the telecommunications services industry in each country has often involved sole sources of supply, and virtually unilateral decisions on equipment design, leaving the customer little or no choice in the telecommunications equipment installed on his premises. This pattern is in sharp contrast to the fierce competition on peripherals (terminals, storage devices, etc.) which characterized the early days of remote data processing. A move to establish a similar monolithic structure of supply in computers and computer peripherals, known as "fencing," was viewed with total disfavor and eventually was abandoned.

The crucial case fought in the USA on "foreign attachments" provided the beginnings of a similar breakthrough in peripherals in the teleinformatics sense. How such conflicts were and are being resolved under different telecommunications monopoly structures is an important element for study.

Circuit Costs

In remote data processing, the telecommunications cost element was and is a very substantial part of the whole cost of the transaction between computer and terminal or computer and computer. The cost of circuits either leased, or rented as in the case of a dialed telephone call, was naturally solely the business of the telecommunications administration concerned. International costs were governed by a complex series of CCITT *recommendations* which while not mandatory, are primarily designed for regulating payments between administrations for international telephone circuits. The high level of charges for circuits for international data processing, particularly in Europe, and the arbitrary nature of these charges was a source of dissatisfaction in the EDP industry. In the USA, there was a greater flexibility owing to the lack of national boundaries but also to the beginnings of a competitive situation brought about by successive FCC rulings favoring the entry into the data communications market of organizations other than AT&T, as so-called specialized carriers and later value added carriers. This resulted in circuit costs five to ten times cheaper than for equivalent distances in Europe.

The Growth of Data Networks

One of the results of the successive loosening of the monopoly situation on data communications in the USA was the boost given to companies specializing in data networks, to whom the telephone common carrier was forced to rent circuits to which the companies concerned added value in the shape of packet switching or other facilities. In Europe, computer telecommunications could only be provided at that time (the mid-70s) by expensive private networks which could only carry the traffic of a single organization or a so-called closed user group. Thus, in addition to the greater cost of the circuits themselves, private networks were much more costly than their American counterparts because they were unable to re-sell the data communications facilities they created to third-parties. It was not in fact until EURONET, a cooperative venture between a consortium of PTTs and the European Economic Community, became operationally possible in the late 70s that Western Europe had any kind of cheap data network facilities, limited to a single application, database interrogation. This development, which required agreement on service standards and network protocols (and to some extent on charges within the network), has rapidly led to national PTT-sponsored data networks, internationally connected by gateways. An in-depth comparative study of cause and effect in development of data networks in Europe and the USA might throw a great deal of light on how each type of organization of monopoly is able to adapt to a rapidly-changing environment. The question may be asked: given that there was very little adaptation to change (in the shape of the emerging international data processing industry) among the European PTTs in the 60s and early 70s, and that we now note an increasingly rapid adaptation to new technologies, new service ideas, and other entrepreneurial tendencies, how have such changes in policies and management attitudes come about with very little structural change?

Broad- band Telecommunications

The possibilities of the new generation of satellite telecommunication systems, giving relatively inexpensive and continent-wide services such as rapid full text transmission, mixed video and computer teleconferencing, direct TV broadcasting and the like are already with us. In North America such ventures as the Satellite Business Systems Corporation are now fully operational, and in Western Europe, the European Space Agency will begin launching the regional European Communications Satellite (ECS) system in 1983. A special sub-group of the CEPT has been formed to work out how the new service possibilities can be integrated into Western European telecommunications. The new technical possibilities are such that individual large users such as major corporations could carry out all their telecommunications requirements without use of any of the traditional ground base telecommunications facilities such as has previously been necessary in telecommunication services by satellites. There is thus a direct conflict between regional satellite communications and existing ground base facilities. It will be interesting to see how this conflict can be resolved while allowing the user to reap the benefits of the new technology but at the same time preserving all the monopoly features of present Western European telecommunications policy. In this connection one may note that British Telecoms has recently announced an agreement with Satellite Business Systems in the USA to provide British access to SBS facilities.

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COMMUNICATIONS NETWORKS—THE FUTURE FOCUS OF INNOVATION

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There are two mainstreams in the worldwide development of communication networks. One is the extension of broad-band transmission beyond the frequency capacity through space by means of coaxial cables, called "cable TV." The other is a completely new utilization of the existing telephone network by interactive, computer-based, generally accessible text, data and graphics transmission, where the information is displayed on conventional TV screens. Confusingly, this system is named differently from country to country: videotex, Prestel, Teletel, Telidon, Bildschirmtext, Captain.

Communication satellites will play an important role in narrow-band and broad-band transmission, especially in large countries with long distances between suppliers and receivers or clients. Satellites with different technological layouts can serve either distribution systems or switched systems.

The extended distribution systems (cable TV) have so far not led to considerable innovative impulses. They have tapped certain consumer markets, mainly in North America, where uninterrupted TV films and more sophisticated or special programs are rarely offered by the commercial TV networks. Cable TV is not as widespread in Europe as in America.

On the other hand, interactive videotex systems have been mainly pushed by European firms and PTTs and could offer a remarkably large field of innovations. The trend toward videotex systems coincides with the general trend toward office automation and computer networks. It has, of course, the same origin: the amazing progress in microelectronics. As mentioned before, the main innovative features of the videotex systems are simple and general access through the telephone network, the unsophisticated terminals, i.e., inexpensive TV sets and simple keyboards on the one hand and digital data handling, digital switching and the interaction of computers with large information storage on the other.

It seems very likely that during the next decade quite a number of new or improved services will become available. Field trials in Germany with the Bildschirmtext system are already demonstrating the noteworthy acceptability of banking and insurance services, news services, new types of entertainment, and last but not least, consumer information and direct ordering of goods. But the focus of innovative services may very well rest in business communication by means of office computers, so that data, messages, software, graphics, statistics, etc. can easily be transferred between offices within an organization or between organizations. In the course of this development, the working hours or working places of "information" workers could be partially transferred to homes, with quite an influence on social structures.

At present there is a general technological trend towards the digitalization of the telephone networks. The reason for this is simply much higher efficiency compared to the existing systems of separated voice and data transmission. A digital telephone system could integrate the transmission of a number of services over a single technical system (Integrated Service Digital Network). Because the standard channel of an ISDN will have a transmission capacity of 64 kbit/s the present videotex systems, which work with about 1 kbit/s, can be boosted considerably in their capability for business and private communication services. High resolution TV pictures (not moving) could be transmitted in a few seconds, e.g., to deliver documents or drawings.

An interesting and innovative application of the new interactive, computer-based networks could be the combination of tele-software and video-discs or video-tapes for instructional purposes.

A further step into an even larger field of innovations could be taken if the integration in future networks comprises narrow-band and broad-band services. This is conceivable because in addition to the progress of microelectronics, an enormous transmission capacity for digital signals by glass fibers has been demonstrated so that the ISDN idea can be expanded to practically every kind of service from data to motion-picture transmission. The innovative clue of a broad-band ISDN is, however, that it would be a switched system which is also able to distribute TV programs. Such a system could, for example, connect any client of the network to another by a full broad-band channel. In this way the old dream of the picturephone could be realized, and many other services as well. From what can be seen today from an economic point of view, the market for such services is not tremendously large. Therefore the investment into a broad-band ISDN on the basis of glass fibers can be amortized only over a long period of time. However, countries that have not yet invested heavily into cable TV networks might consider killing two birds with one stone by installing a very modern communications infrastructure which contains the extension of the TV system.

A fascinating potential of a switched broad-band system that is digitalized and based on a computer network are educational services, where all kinds of instructional material could be made available at any time and any place. The dream of lifelong learning that might be even fun could become reality and partially counteract the dull passive use of today's TV.

The future communications described in this perspective can be called the focus of innovation. If the "informatization" of society has any concrete meaning it will be intimately linked to the technology of these networks. There is no other future field of innovation as large as information handling and transmission, because in the past this field has lagged behind in rationalization compared to industrial production. Only now through basic innovations like microcomputers, lasers, and glass fibers is a technology becoming available that allows use to be made of this rationalization potential in future years.

BROAD-BAND TELECOMMUNICATIONS: SOME POTENTIAL APPLICATIONS TO STI TRANSFER

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1. Background—Telecommunications in STI* Distribution

The use of telecommunications is fundamental to on-line information retrieval; the fact that the marriage of computer and telecommunications technology resulting in this offspring is a comparatively recent event is however often forgotten. While the original development took place in the mid-1960s, the first full-scale operational experiments in on-line interrogation of STI databases occurred not more than twelve or thirteen years ago. At that time, especially in Europe, telecommunications providers were not particularly interested in remote electronic data processing in general, and on-line information retrieval in particular, and in consequence, much of the early technical development in computer networking, and in organizing an infrastructure for on-line services, was undertaken by individuals and organizations not part of the formal telecommunications establishment.

While the situation has now changed, the rapid pace and rather ad hoc nature of the development of teleinformatics and on-line information retrieval has essentially been conditioned by the use of what was available, or what could quickly and (relatively) cheaply be developed. One result is that the pattern of teleinformatics as applied to on-line, and the kinds of information distribution services we think of in this context, are at present limited by the performance characteristics of analog telephone circuits provided by twisted pairs of copper wires. We have all read of the revolutions in telecommunications services, just around the corner as a result of digital switching, fully digitalized circuits, optical fibers, leading to the "wired city" concept; perhaps it is now time to begin to look systematically at the way in which new telecommunications technologies affect not only how we do it, but what we do in the electronic transfer of ordered information. This paper is concerned with the possibilities in the use of broad-band, multi-destination telecommunications techniques such as communications satellites.

2. Characteristics of Satellite Telecommunication Systems

The technical characteristics of satellite telecommunication differ in several important respects from those of the terrestrial systems, in an informatics context. The following are brief notes on the main important differences and their consequences.

*STI = Scientific and Technical Information, but the term also includes information in other fields, e.g., economics, finance, etc.

Bandwidth

Data transmission via satellites uses advanced radio techniques offering the possibility of very wide bandwidth, and therefore of data rates greater by several orders of magnitude compared with those provided by telephone-type circuits. A single satellite transponder can provide data rates of several tens of megabits per second, and current telecommunications satellite designs employ a whole series of transponders in the same satellite. In comparison, the maximum data rate achievable by a single twisted-pair telephone circuit is 9.6 kilobits per second. The satellite bandwidth possibility allows one to consider applications such as the rapid transmission of pictorial data (TV, high-resolution facsimile, etc.), and from the computer point of view, massive file transfer.

Coverage

Communications satellites, being geostationary, have very wide coverage, even when their power is concentrated in the form of spot beams, etc. Within the average area, a single signal may be received by any number of stations without detriment to use as a point-to-point medium. In the latter respect, the use of resources is completely distance-independent, although as the transmission path is very long, there is an appreciable transmission delay, which makes satellite communications less attractive for applications in which individual blocks of data are small, i.e., of the size of the packets currently used in terrestrial packet-switched networks.

Frequencies Used: Trade-Offs

The frequency range most commonly used for international telecommunications satellites is such that for efficient use of the satellite resources, large ground stations employing dish antennas several tens of meters in diameter are necessary. These are expensive and therefore tend to be used as concentrating transmit-and-receive stations serving large areas, with the disadvantage (from the telematics applications point of view) that the nature of the traffic is constrained by the characteristics of the terrestrial telecommunication systems feeding the ground stations. However, some regional communications satellites are being designed to operate at frequency ranges (11-14 GHz) that permit the use of much smaller antennas (3-4 meters in diameter), and receive-only ground stations of this type cost only a few thousands of dollars, making is possible to conceive of systems almost totally independent of conventional telephone-circuit distribution systems. The use of this technical possibility to provide a new type of door-to-door high-speed, high-density data service may, however, be constrained by regulatory problems.

3. Possible Applications in Information Transfer

There have been many studies of the application of telecommunications satellite systems to areas other than those of traditional telecommunications services and TV broadcasting, for which existing operational satellite systems are mostly used. Satellite Business Systems (SBS) in the United States has, for example, devoted very considerable resources in planning a whole range of integrated business communications services via domestic (i.e., regional) satellites. In the field with which we are most concerned, the on-line interrogation of information databases, the American Institute of Physics and NASA have carried out a joint experiment in the use of both satellite and terrestrial communications in delivering document copies requested as a result of on-line searching. Unfortunately, no conclusive results were obtained owing to problems beyond the scope of the experiment itself. The suggestions which follow are based on work done by a European international working group (COSADOC), established by the European Space Agency to study how communications satellites could be used in the transfer of scientific and technical information, in the wider sense of that term. In particular, COSADOC was also asked to suggest experiments and demonstration projects which might form part of experimental activities using the agency's Orbital Test Satellite (OTS), the forerunner of the operational regional communications satellite system (ECS), which ESA is launching for the European PTTs from 1982 onwards. While the COSADOC material has not been formally published, S. Hanell (1980) has summarized much of the work.

Pictorial Data Transfer

An early application examined by COSADOC concerned the requirement for rapid distribution of a large number of images of the earth's surface produced sequentially by earth resources satellites; day-to-day coverage of agricultural crops, movements of pests such as locust swarms, large-scale vegetation damage in remote areas, marine pollution, etc. require the identification of individual images, or series of images, and their rapid transmission to locations where the information can be analyzed and acted upon. ESA's Earthnet program provides for the initial capture and digital archiving of data in Italy and for image identification using the facility of IRS Frascati by means of the QUEST system. It was therefore easy to conceive of an experiment in which these data were distributed to user centers using a high-speed satellite link in place of postal delivery of photographic images.

The experiment is an example of the logical division of functions in information supply between narrow-band terrestrial networks (ESANET, EURONET) to identify and locate information by normal I/R techniques, and broad-band networks more suited to handling high-density, high-speed bit streams to deliver the actual information. Centers in Germany, Sweden, and the UK are taking part in this experiment.

Full Test Document Delivery

This was thought by many to be a priority area for broad-band networking in the provision of scientific and technical information. Whether or not we start from a completely digital version of a document, perhaps as an output of electronic publishing, or whether an existing printed document must first be digitalized either in coded character or facsimile format, transmission of the text by narrow-band networks presents many problems. A proper term of the requirement for rapid document delivery may be met by terrestrial networks if tariffs more appropriate to steady transfer of high volumes of data than those associated with present, low volume interactive traffic can be introduced. There will, however, remain a number of possible requirements which cannot be met by terrestrial networks, for example, on-line browsing or even retrieval from full-text. For these we will require transmission rates of one megabit per second or better, and these present no problems to a satellite link.

It may perhaps be pointed out that the hardware requirements on the ground for effective use of the high data rates obtainable via satellite are more complex than those for terrestrial networking, and it will be some time before inexpensive user terminals providing all the necessary facilities will appear as off-the-shelf items.

In view of the interest of the EEC in full-text document delivery, the details of a joint experiment using ESA's OTS are being worked out between the two organizations: this experiment, known as project APOLLO, is intended as a test-bed for full-text document delivery via satellites, which can be used for a number of different types of information resources. Also, project APOLLO will provide a good example of the complementarity of terrestrial and satellite networks in a single system (narrow-band interactive retrieval and broad-band real-time supply).

Distributed Database Systems

The infrastructure required for present day database and information retrieval operations is expensive, involving many large computer systems, often with much duplication, and highly skilled manpower for maintaining and updating databases and software. In addition, an equally complicated telecommunications infrastructure in the shape of national and international networks, gateways, and the associated protocols and switching hardware and software is necessary. The possibility of multi-destination, wholly distance-independent broad-band transmission systems, however, permits us at least to think of another way of organizing the system as a whole. For example we might conceive of a few large "database farms" where the work of file maintenance and updating could be centralized, thus gaining economies of scale, and which would provide, by satellite links, local mini-centers (small secondary hosts) with "throw away" portions of databases for searching by families of simple terminals. While appearing revolutionary, not to say utopian, this suggestion is in fact only an extension, taking advantage of the broad-band properties of the satellite link, of something which has already been done in terms of a hierarchical connection between two host computers. While probably not appropriate to present circumstances in industrialized regions, in which infrastructure already exists and would be difficult to modify radically, it may be that the concept would be applicable in developing regions, where often a lack of infrastructure is the determining factor in the slow pace of information system development.

Other Possible Applications

COSADOC also considered other possible applications of broad-band satellite techniques in the whole process of creation, location, and supply of scientific and technical information in the widest sense of that term. It was noted that the basic trend in use of new technology, from the earlist days of machine-readable databased interrogated by serial batch processing, has been to improve the speed of locating and retrieving information. On-line systems provide the user with relevant references or data in half an hour, but in spite of on-line ordering, leave him to wait for a couple of weeks or so for full-text to arrive on his desk. Electronic delivery of full-text within a few hours will be a great improvement, but we will still be faced with the very serious gap in time between the creation of new knowledge and its appearance in retrievable form. In many branches of applied science, particularly those interdisciplinary fields directly relevant to the economy, the user would like to know not only the results his peers achieved a year or more ago, but what they are doing now. COSADOC looked at some of the links in the chain of creation and distribution of information which might be delay-producing, and concluded that satellite communications did in fact offer a real possibility for improvement. Without disturbing the traditional publication process, cheap broad-band communications could do much to speed up the assembly of the primary material and its processing for inclusion in databases and databanks, and also in distribution of updates: batching at various stages along the chain might be avoided.

However, it was recognized that these could only be partial solutions, and that the basic constraints lay in the publishing process itself. New forms of information dissemination based on text processing and electronic publishing technologies are certainly possible and the properties of broad-band data transmission are ideally suited to these new forms. An all-electronic system of information recording and distribution might not, however, be consistent with other basic objectives of scientific and technical publication. In any event, these are larger issues than can be dealt with within the scope of this brief note. Those interested may find the notes on a possible "new look" for scientific and technical information dissemination of some relevance (Page 1981b).

4. Economics

The workshop and demonstration of electronic document delivery which took place in Luxembourg in December 1980 (Page 1981a) clearly highlighted the cost problems involved in electronic document delivery using terrestrial networks such as EURONET. Even if it were necessary to digitalize the text before transmission, the cost of digitalization and reconversion into the printed form at the user's premises would be rather small in operational circumstances, amounting to something on the order of 0.1 to 0.15 European Accounting Units per A 4 page for each of these operations. However, if pages were transmitted over EURONET with existing tariffs, transmission cost per page would not be less than about 1.3 EAU for digital facsimile; this is probably the only practical system for immediate application. The dominant feature in these costs is the volume charge element in terrestrial network tariffs. These were designed for low volume interactive traffic where probably no more than a few tens of thousands of characters are generated per on-line hour. The transmission of full-text requires the steady passage of some 200 kilobits per page for facsimile, representing about 2500 characters with little or no "silent time" during the whole transmission. Probably, therefore, the economic viability of electronic document delivery using terrestrial networks can only be assured if a very different tariff structure is developed, reducing these costs to provide a total page charge more in line with what users are prepared to pay for existing photocopying services.

Delivery of full-text via satellite systems must be subject to the same kind of competition from existing services, except that an entirely new element might be added, that of on-line browsing. User reaction to this possibility, in terms of what they are prepared to pay for it, and indeed user willingness to pay for overnight delivery in both the satellite and the terrestrial network delivery options, are matters which current plans for experiments and pilot projects are specifically designed to explore.

While it is difficult to make any guesses about the future development of tariffs structures for these kinds of applications in terrestrial networks, it seems entirely impossible to make any statements at all about satellite system tariffs. The INTELSAT series of international telecommunications satellites has been in operation for some years past, but charges for data transmission do not seem to be a function of the prices charged by INTELSAT for the use of the space segment: instead, the telecommunications administrations appear to charge the same rates for leasing a data circuit between two points, regardless of whether INTELSAT or an undersea cable is used. It has already been noted that this type of communications satellite requires the use of terrestrial networks for input to and output from the space segment portion of the system, a factor which will obviously increase the cost (and the price) of the link as a whole. In one instance, the total cost for a megabit channel was reported to be eight times the INTELSAT charge for the space segment alone. Costs should undoubtedly be less in the case in which a three to four meter send-and-receive ground station costing some tens of thousands of dollars is working to small receive-only stations costing a few thousands of dollars each, since there will be little or no additional terrestrial distribution requirements. To what extent this will be reflected in prices to the user is unknown. The degree to which broadband telecommunications media can fulfill their promise in information dissemination is less dependent on the cost-effective solution of technical problems than on regulatory and tariff policy aspects.

5. Other Future Possibilities

This paper has been about satellites as an example of how broadband telecommunications could potentially alter our basic concepts of STI transfer. Advocates of other teleinformatic applications embraced by the "wired city" concept could no doubt show how this or that combination of other telecommunications technologies could play an equal or even greater part in the future. In systems analysis we try not to draw the system boundaries so tightly that we automatically or unconsciously exclude a valid range of possible solutions. Therefore, just as I consider that we are perfectly entitled to ask the question "why publishing?" in trying to analyze methods of reducing the delay in disseminating new scientific knowledge, we should also be prepared to ask the question "why telecommunications?" in the same context. Developments in mass storage (for example the digital optical or laser disk), in electronic publishing and microprocessor revolution make it possible to conceive of information distribution systems in which the end user can quickly and easily be provided with a coarsely preselected collection of primary information in digital form which he can then use as a part of a personal database for searching on his personal computer. An integrated information system of this kind is described by Haefner (1980) and is also summarized in *Electronic Document Delivery: Proceedings of an Exhibition and Workshop* (Page 1981a). At least one package including search system, hardware, and the primary literature is already on the market.

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TELECOMMUNICATIONS SUPPORT THE PRINTING INDUSTRY: A CASE STUDY OF THE LATEST DEVELOPMENTS IN FINLAND

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ABSTRACT

Interaction between the enterprises and branches of the information sector is evident. There is a growing demand for information products and services, and there is synergy between the various sectors. Particularly important are the mutually supporting interactions between computer industry, data processing, telecommunications and graphic communications. The supporting and competing effects of the interactions between the two last mentioned sectors are analysed by means of a case study of the Finnish newspaper business, which is one of the most successful mass communication operations as regards growth and innovation. Other subsectors of printing are also presented briefly. The study seeks to explain why newspapers are such powerful users of the new technology. Text processing systems, news gathering and distribution problems are central reasons, but further development will involve new areas, such as digital picture processing, distribution and assembly – the combination of design, images and text. The needs of the newspaper product and production seem to increase simultaneously with the capability of using the increasing supply of electronics and telecommunications. The competing effects of the so-called new electronic media, such as videodiscs, videotex, teletext (broadcast videotex) or cable-TV, are also perfectly apparent, but their competitive powers – especially in the more local newspaper field – depend on the cost of the electronic operations. The cost of future data management technology (memory, special processors and networks) and telecommunication channels is relevant.

BACKGROUND

Printing industry and its main products – newspapers, magazines, books, forms and advertisements – belong to the mass communication sector, which is a part of the information sector. Depending on tradition and other factors, the printing industry constitutes about 5–7 % of the value of production or value added of all the manufacturing industries. The size of this share is less important than its significance as a channel of news, culture, entertainment, politics and advertising. The information role cannot be measured quantitatively, though it continues to grow in all countries. The industrial role can be measured indirectly by paper consumption or by business volume.

In 1981, the total turnover of the printing industry in Finland was about 7 000 MFIM (million Finnish Marks). With the corresponding value for telecommunications, about 3 000 MFIM, it makes a total of roughly 10 000 MFIM for mass communication – including some minor sectors, such as audio and video recordings, cinema and outdoor advertising, excluding certain non-mass communication services of the telecommunication sector. The consumption of mass media is relatively big in Finland, and it is still growing, contrary to some other countries, particularly in the less competitive products such as national magazines or newspapers.

Between 1970 and 1978 the growth of the mass communication business in Finland, in practically all products, was higher than ever before [1]. This is at least partly due to the geographical conditions, demographic features, e.g. small families, the growth of advertising and new technology. Colour production in the television services and offset printing and text processing systems in the newspapers have been the main breakthroughs in the 1970s. Experiments and small-scale production have been carried out in cable-TV, videotex and teletext by both private groups and government offices – i.e. the national PTT of Finland (videotex) and YLE (Finnish Broadcasting Company), the government-controlled television company (teletext). Graphic arts enterprises, especially newspapers, have generally taken an active interest in the local videotex and cable-TV companies of the private sector.

Telecommunications and graphic communications have two interaction effects influencing simultaneously but with somewhat different timing:

- Telecommunications support the printing industry and the graphic communication products by providing for more flexible gathering, transmitting and processing of information. Fig. 1 gives an analysis of certain existing supporting services used in modern newspaper production. The effect is quite evident and is still growing, though it has not been brought up for discussion much.

- Telecommunication services may compete with some graphic communication products. Television, cable-TV and radio – particularly if commercial advertising services are incorporated – compete with national or local graphic products, such as newspapers or magazines. The effect is in many cases weak or non-existent. There will be more competitive effects in future, when the new electronic media become cheaper and more comprehensive.

The effects of the latter interaction can be seen in differences in the channels of national advertising costs and in the differences in the relative household coverage of the competing media. For example, the share of newspapers of the total national advertising costs varies greatly. It is low in the USA (about 25 % in 1979) where the other media have no advertising restrictions, and it is higher in countries like Finland (about 57 % in 1979) and Sweden (77 % in 1979) where only television advertising is allowed under rather strict control (Finland), or where even that channel fails (Sweden). In spite of these real competition effects newspaper business has developed very well in the USA, Finland and Sweden.

We might even construct a third interaction effect: The supporting effect of new printing or graphic communication methods on the coming telecommunication services – those which need hardcopy output or other graphic presentation forms. That is, however, a future effect without any greater influence for the present.

Telephone	**Reporters Portable VDTs Local editors**
Data networks	**Picture data International news agencies**
Telecopy	**Ad dummies Layouts Manuscripts**
Telefax	**Pages or newspaper (remote printing)**
Teletex or word processing	**Ad agencies or customer text Administration**
Videotex (Phone and data nets)	**News gathering Editorial back- ground information**

Fig. 1. Supporting services for newspaper production.

Therefore, the highly simplified discussions and visions of the new electronic media being substitutes for the graphic communication products can be replaced by more complicated future scenarios with many alternatives, and new combinations of electronic and graphic communications.

GRAPHIC COMMUNICATION PRODUCTS

To help understand the information flow and processing we have to present the products of the graphic communication. The main products are:

- *Newspapers* are national or local, and contain mostly news and advertising. They are published daily or only 3–4 times a week. A broadsheet newspaper page contains up to 50 000 characters (8 bits) of text and up to $5\,000^2$ pixel*) (8 bits) of image resolution or even more, if a better paper quality than the standard newsprint is used. Practically all Finnish newspapers are printed in web offset presses. The daily production contains some colour advertising will become a steady business in the 1980s. Circulations range from a few hundred thousand to less than 10 000 copies of the smallest local papers. The number of pages varies between 10 and 100. By multiplying some of the numbers mentioned above we can estimate that the daily number of characters processed by a big newspaper equals $5 \cdot 10^6$.

- *Magazines* are mostly national, and represent a general interst or outline a special interest profile. They are published weekly or monthly – the smallest frequency is 4 times a year. Circulations vary in about the same range as with newspapers. Magazines contain much less text and more colour pictures and advertisements than newspapers do.

- *Books, commercial prints, forms and office copies* are more heterogeneous groups. Many printing plants are highly specialized to produce one or two main products. The number of copies is relatively small, mostly a few thousand, and the publishing frequency varies. Hence, production must be very flexible. Both the prepress processes and the press operations must allow a daily production of 5–20 jobs in two shifts (Finland). Most jobs consist of information for small target groups rather than wide national reader groups. There are also products distributed within one company only.

It is evident that due to its daily publishing frequency a newspaper is the product with the highest internal communication needs. Newspapers are also the biggest single product group within the Finnish printing industry, accounting for about 40 % of the total turnover in 1980. Therefore marketing and development of systems have been directed to newspapers, particularly as regards text systems. Before the 1970s there were only a few production installations of photocopmposition, and it soom became evident that a computer front end system is necessary for gathering the text from various sources for the final composition output. Composition systems aimed at the so-called before-output-correction. Later editorial systems were developed with many interactive working features, database and telecommunication capabilities.

This is seen in Fig. 2 as the first period of system evolution, right now we are in the middle of the period, and newspapers are installing their first ad-systems for com-

*) pixel = picture element

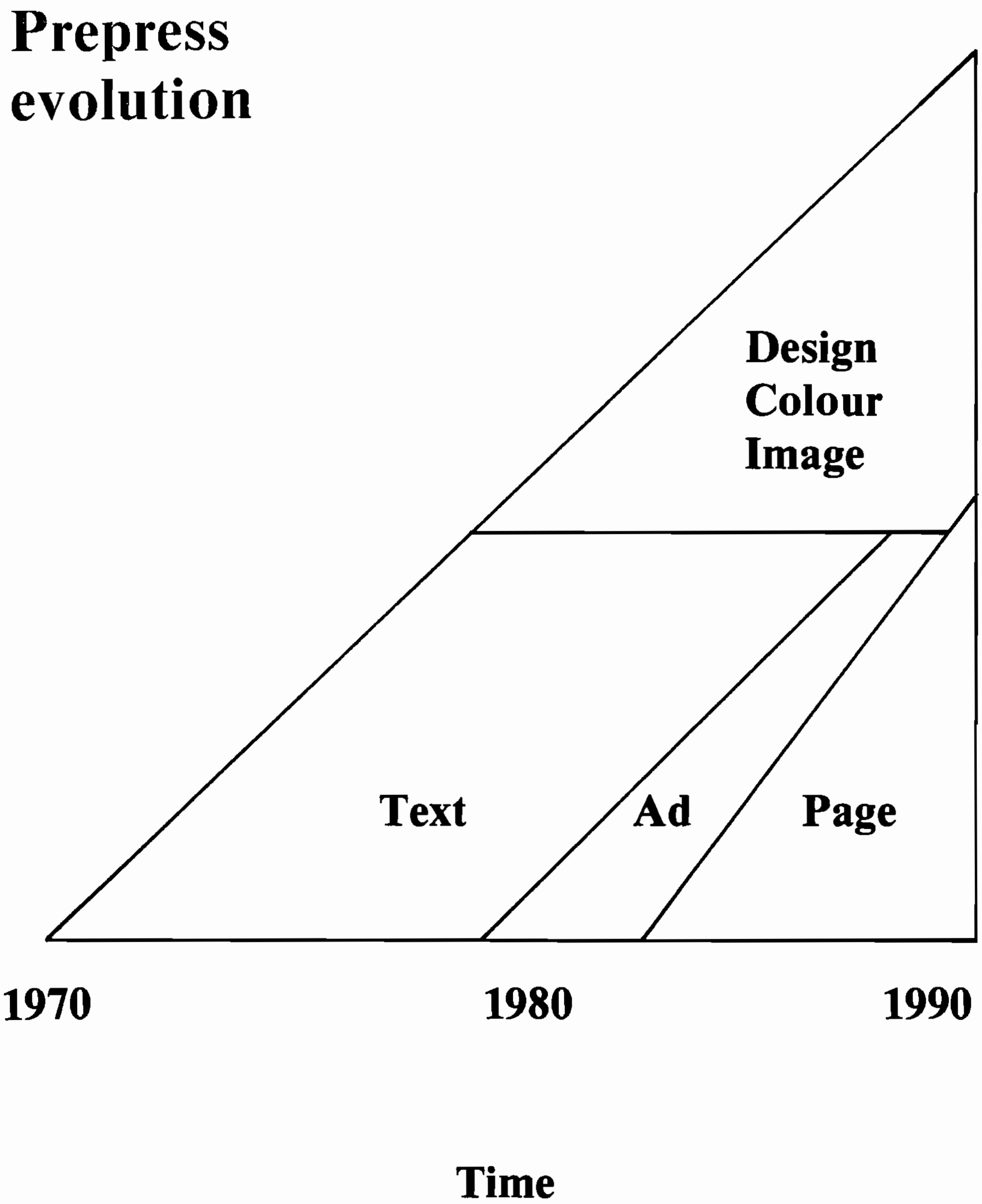

Fig. 2. Prepress evolution.

plicated display-ads, logosystems and digital picture processing systems. Text systems also include visualization displays or page makeup terminals. In addition, text systems have to be able to feed ready text blocks to picture systems, where they are assembled to colour pictures to form colour-ads or magazine and brochure pages – the most complicated of all graphic communication products.

Today there are already more than 200 text and picture systems of varying sizes, functions and complexity only in Finland. Accordint to the NATS Register, which covers the Scandinavian *newspaper* printing plants, there were about 200 *text systems* in 1981, whereof about 50 in Finnish newspapers.

NEWSPAPERS NEED TELECOMMUNICATIONS

Figure 3 shows a daily newspaper operation. The various text and picture sources have to communicate with the editorial and advertisement departments. There is much more text and picture traffic than the amount corresponding to the final newspaper contents. Consequently, the mass memories must be strongly overdimensioned and well-backed-up. In fact, text systems use 60 Mbyte and picture systems 300 Mbyte discs. Most text systems have two parallel production lines, and ad-production and pagination may require special working stations or subsystems.

This is, however, only the beginning of more massive needs, which arise i) locally when systems start forming nets and ii) at longer distances, where picture, page, ad and videotex traffics start using data networks, which will happen in the next few years. A medium-sized Finnish newspaper with editorial text systems today needs about 20 modems. Today's teletraffic uses mainly fixed or dialed telephone lines and some telex (news agencies). Data networks and later on integrated networks – maybe in the 1980s and after – will offer more speed and lower unit costs.

The newspaper is a good example of how information processes can become substitutes for physical mail, travelling and person-to-person phone calls.

Later when the rising distribution costs force newspapers to develop distributed printing operations by using remote printing presses within their circulation area, there will be digital pagefax transmissions. Though not so much in Finland, such technology is already used in many countries – France, Italy, Sweden, Denmark, the UK, the USA and the USSR – for transferring complete newspaper editions of national newspapers. One might think that the newspapers could share their press capacities in different cities. This is, however, practically impossible for competitive reasons and because of the differences in the press lines, which are tailored to fit the page and colour needs of the main publisher.

Multimedia publishing of news and ad-information gathered and processed by the newspapers will be possible in the near future. The new media, such as videodiscs, videotex, teletext (broadcast or cable) or homefax, will create new system and telecommunication needs.

PROBLEMS IN THE TECHNOLOGY TRANSFER

A big limitation to the transfer of technology will be the structure of the newspaper industry, which is fairly similar in most countries. In Finland there are about 90 newspapers, but only 25 daily newspapers. These companies have annual turnovers of FIM 20–500 million. System investments are nationally about FIM 100 million per annum and in the biggest dailies about FIM 50 million. This is about one fourth of all

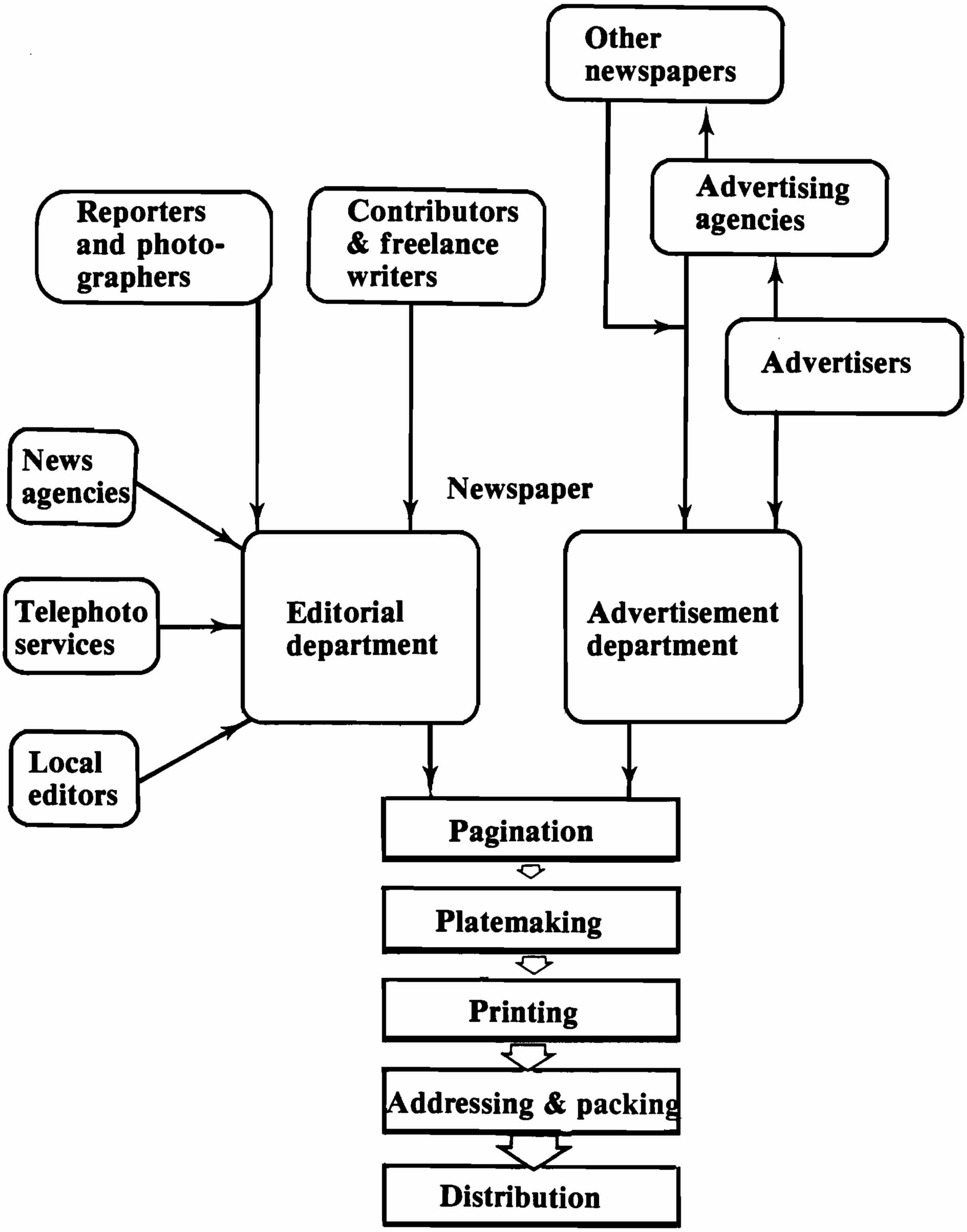

Fig. 3. The stages of newspaper production.

the investments and 1–2 % of the annual turnover. Financing is not a problem, only system investments are not yet recognized to be one of the main strategic powers. Thus decisions are sometimes too conventional and do not cover all of the future needs. On the other hand, the most active companies participate as vendors in the development projects of new technology. This is particularly true in Finland as regards both text and picture systems of newspapers. At the same time and within the same areas there are companies blindly using and others actively transferring and creating technology. It is self-evident that the last mentioned will – if their risky efforts are successful – reach better strategic positions in future. Such know-how competition will also have unpredictable consequences within the supporting and competing joint overlaps of graphic and telecommunications.

Characteristically, some of the system companies are owned by big concerns operating in electronics and telecommunication. In Finland, the only text system company, Typlan Oy, became a part of the Nokia group in 1981, though its other owners still belong to the printing industry. International manufacturers of films and photographic supplies, e.g. Kodak and Agfa-Gevaert, have also recently acquired well-known system companies – Atex and Compugraphic respectively. Compugraphic is the biggest photocomposition manufacturer. Harris is a big company specializing in the information technology including both graphic and telecommunication products.

There are also clear differences in how effectively the systems are used by different user companies. It seems that big and medium-range newspapers have more benefits of the system productivity features. On a very large scale system planning problems become evident. Purchasing is effected in many stages over a number of years, and the rapid changes in technology make the relevant future requirements almost impossible to fulfil.

The ever-rising level of technology presents another problem. There is a clear difference in the level of technology between text systems, picture systems and integrated systems for newspaper production. This applies to processors, peripherals and software. Personnel education and training, and new experts are needed in correct proportions.

Finnish newspapers are characterized by one important feature: Almost all products are morning papers, which means that they are mailed or distributed to subscriber boxes address by address. This represents a powerful service and know-how, but also high cost. The advertising power is great, because there are more readers in each home and morning reading is considered to be the most active consumption. An analysis (4) of the distribution costs shows that the share of transportation is surprisingly low, i.e. about 10–15 %, and the actual distribution, mostly salaries, is the reason for the high cost level.

CONCLUSION

Support and use of telecommunications by newspapers have been analysed in this paper by using the Finnish printing industry as an example. At the same time, new media, i.e. cable-TV videotex and teletext are being developed. The competitive effects of the new media on newspapers seem to remain very small in the current decade. The prices of new media services are still relatively high and the commercial effects, advertising services in particular, uncertain. There are many possibilities for the newspapers to keep their production costs at the level accepted by today's consumer. The prepress systems for text and picture processing will make page production faster and more flexible. Subscriber systems and a more selective distribution are also coming. Still somewhat uncertain is the possibility of remote printing, which would save part of the transportation costs. On the other hand, transportation is only a minor part of the really high morning distribution expenses. Development work is continued in Finland for further transfer of new technology to the prepress systems for integrated page production. Printing press automation and postpress systems will be objects of more research and development, leading to commercial system products, as we already have them in text processing systems.

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THE FINANCING OF NEW TECHNOLOGICAL INVESTMENTS

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1. THE ALLOCATION PROBLEM

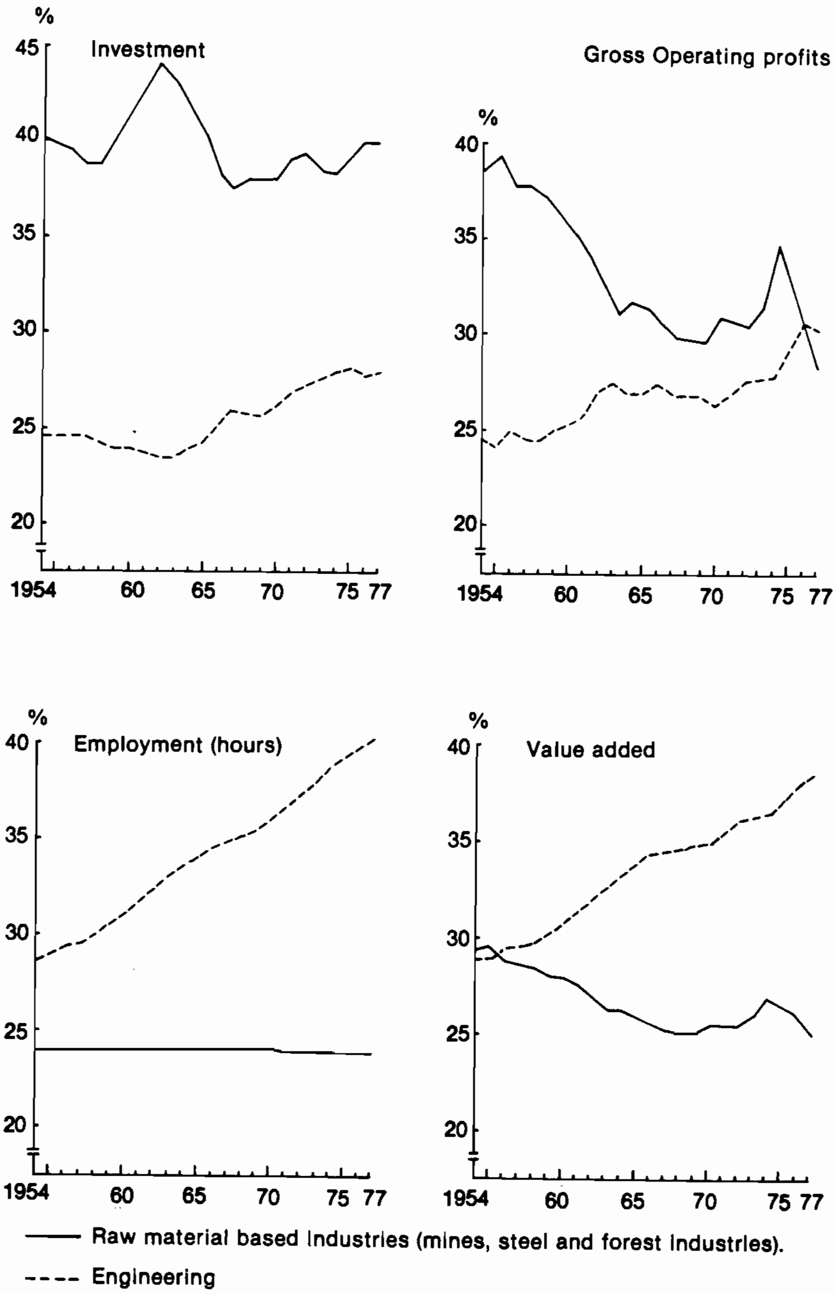
1.1. An Illustration

The Swedish economy during the last few years has frequently been referred to as suffering from an allocation malaise. The full diagnosis of that illness is yet to be seen but a few illustrations of the symptoms will highlight the issue.

First, Figure 1 includes four diagrams. The left side shows that the raw materials producing sector - nowadays often recognized as a crisis sector - for the entire post war period has been drawing a constant fraction of total labor and investment resources allocated to all manufacturing. At the same time the raw materials producing sector has been providing the nation with a declining share of total manufacturing profits and value added (right hand part of Figure 1).

In more simple terms this means that a larger total manufacturing output should have been expected from a different allocation of resources (more to other industries) and more new resources (profits) for future investment and growth would have been generated if less resources had been made available to declining firms in the raw materials sector. The raw materials producers are predominantly of the large size, capital intensive, low product technology type that have fared less well in international markets during recent decades *). The decisive allocation variable is investment in a broad sense and those factors that guide financial resources to particular investments.

*) See Eliasson-Carlsson-Ysander (1979, chapter 6) and Ohlsson (1980)



Source: Eliasson-Carlsson-Ysander (1979)

Figure 1

Shares of the Engineering Industry and the Raw Material Based industries in investment, employment output and profits in Swedish manufacturing 1954-1977. (Present, moving 5 years averages.)

The main role of financial institutions is to allocate capital resources from their sources (the savers) to various end uses. A much honored question in economic (historic) research is whether the industrial revolution was, or fast economic growth in general is caused by a particular financial organization of an economy or whether economic growth simply forces the needed complementary financial structure to develop. Anyhow, parallel industrial and financial structures tend to exist in different countries and the absence of organized capital markets normally witnesses the absence of industrial advance as well. But cause and effect are difficult to identify since we are concerned with long time periods during which many rounds of cause and effect have taken place. The general presumption of this paper is that the efficiency and organization of financial markets do affect the real side of the economy. The particular question raised is whether the finance of new high technology investments should be of particular concern in this respect.

The role of efficient financial markets is not only to allocate resources to the best activities as judged in an ex post perspective but also to deny resources to bad investments. The importance of this resource screening process was illustrated already in Figure 1 and is further emphasised by the observation that at least 50 per cent of total productivity performance of Swedish industry seems to be the result of structural change between firms, rather than technical change at the firm level *). Factor markets (labor, capital etc) are the vehicles for structural change and the introduction of new and superior products and production techniques at the expense of less efficient alternatives.

1.2. New Technology Ventures

The main allocation problem is to get finance to those activities that turn out successful ex post. This is, however, close to a trivial formulation. Success is the result of entrepreneurial competence and very often luck. Our problem is to identify the peculiarities of "new technology" venture finance.

There are two special features. One, new technologies are inherently risky. To be worthy of attention they should yield very high expected returns. This quality, however, they share with a much broader class of activities.

The logical conclusion would be that risky ventures in new technologies require a much deeper knowledge not only by the user but also by the supplier of funds to reduce the risk content of investments. Therefore, and second, these kinds of investments are normally associated with a high degree of internal finance, either through internal profit plow back within firms, equity participation of outside investors or through the supply of ingenuity and work effort by a small group of daring entrepreneurs and inventors, all hoping to earn a large capital gain in the end. A common proposition from many quarters has been that particular, specialized credit institutions that can assess these risky projects and provide finance, need to be created.

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*) See Eliasson (1980) and Carlsson (1981).

It is, however, very important not to get overly fascinated with the romantic vision of the small scale innovative company as the prime mover of technological advance in industry. So far it is not even clear which entities are more inventive, the large managed high technology companies or small companies. Even if innovativeness in a restricted technological sense can be shown to be relatively more associated with smallness than with large scale, the massive technological advance (as we measure it) associated with a prosperous industrial nation is

1. predominantly the result of R&D and investments in large companies and

2. in not very sophisticated technologies as well. At that level one also has to recognize that technological advance

3. consists of a spectrum of factors, generally not thought of as "technical". The management of the company is one such factor and the "management" of the entire economy (policy making, cultural system, incentives etc.) another.

   The larger the "firm" and the more advanced the economy the more important is this third observation. The introductory illustration of the "allocation problem" was intended to emphasize this aspect.

   One particular aspect of risk associated with large, international companies in intense rivalry with new product qualities rather than prices on standard products is the lengthening of development time (the gestation period) in combination with larger risks for product failure *). Even though actual costs incurred up to production and sales may be fairly small the indirect costs for the entire company to be left hanging in the air with an unsuccessful, major product can be enormous.

   Finally, and importantly

4. In small and large businesses alike the major financial requirements do not originate in R&D spending per se but in the overall growth process associated with the launching of a new technology (product, process etc). Even though the case reports will concentrate on the R&D side, the relative magnitude of plant, equipment, inventory and trade credit finance has to be remembered.

1.3 The Large Firm as an Investment Bank

The large western firm can generally be seen as a bunch of small firms held together by a corporate headquarter that operates very much as a commercial and an investment bank **) when it comes to obtaining an efficient internal allocation of available funds. This is where management techniques enter and by this formulation we can also discuss the differences between a small and a large company when it comes to financing high technology investments.

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*) See Eliasson (1976, pp 243-249).

**) See Eliasson (1976, chapter VII:3).

First, this means that much of new establishment activity in fact takes place within large firms.*) Without the financing trouble said to be associated with independent new entry.

Second, one has to keep financial scale and production scale very clearly apart when discussing problems associated with "smallness". Production scale normally determines the size of the investment and the technology risks taken on. The financial scale of the company determines how much risk that can be absorbed. Production scale is a very relative concept that has to be seen in the context of a market. Generally speaking we can say that the twenty or so large and internationally known Swedish companies are large or very large in an international comparison when it comes to plant size but quite small in financial size. They are usually quite specialized producers that some times dominate the world markets in their product range (for instance Atlas Copco, Sandvik and to some extent LM Ericsson). Their high degree of specialization, however, also means that investments in new and superior technologies by the firms themselves or in a competitor firm poses extremely high risks for the firms.

Their relatively small financial size in an international market setting at the same time imposes narrow limits on the capacity to absorb such risks. LM Ericsson and ITT provide a very good case in point. ITT has so far missed out in technological competition with LM Ericsson in their common field, but its large financial size (some 10 times that of LM Ericsson in 1977 measured by sales) means that it can absorb a "mistake" internally and possibly finance a comeback as well. For this reason we have found it appropriate to choose two large Swedish companies to illustrate the problems associated with investments in new technologies, and in one case the new product technology cannot even be called sophisticated or very advanced. Part of the high technology investment for these companies in fact consists in obtaining an economically efficient combination of market size, product design, production scale and marketing organization. In addition to that both companies obviously strive hard to obtain as well an efficient internal allocation of resources that also allows for more spreading of risks than earlier so that an investment mistake in their increasingly competitive markets does not jeopardize the entire company and the efficiency associated with a high degree of specialization.

1.4 The Organization of Finance

Internally generated finance can normally be allocated efficiently within the corporate entity, even though internal restrictions associated with labor-management relations etc. may sometimes slow down the process.

The credit market "manages" the allocation of funds between corporate entities and between firms and other sources of saving. A general and very complex problem has to do with the efficiency of the credit market mechanisms. We will only touch upon this matter here. Three problems will be discussed below. The first has to do with the locking in effect of internally generated funds for tax reasons, the second with the non-market availability of funds for other reasons than long-term efficiency (subsidies) and the third and final question considering all this and other factors (next section) is whether the small innovator with no own funding is as bad off as it is often believed. This is perhaps where equity market finance really becomes important.

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*) See Du Rietz (1980)

It has sometimes been advocated that the development shown in Figure 1 to some extent depends on a tax induced misallocation of resources between companies. Corporate income and personal income taxes place large wedges between the before tax rates of return available within the company and the after tax returns available to share owners when the company distributes profits as dividends. It is easy to demonstrate that highly profitable projects in company A become less attractive than low profit or even loss projects in company B when it comes to deciding on where to allocate internally generated finance in company B. This aspect is particularly important for R&D investments, most of which consist of wages that can be immediately written off. Such factors tend to favour waste and a lowering of internal rate of return requirements. At the same time they make financial risks smaller; losses are immediately lowered by a reduced tax burden on profits from other sources. Hence a large diversified company should be more prone (for tax reasons) to engage in high risk technology ventures than a small company, provided other factors do not offset this inclination. Such factors are the much talked about difficulties in large companies of efficiently spotting future technologies or carrying them through due to conservative bureaucratic organisations. If these are the companies that are currently making the profits, waste and inefficiencies and less growth may follow, and especially so if markets turn against their products *).

One extreme form of such "waste" is the subsidy program for ailing industries enacted in Sweden during the second half of the 70ies. Massive resources **) have been systematically channelled to some low performing companies with a very doubtful future through the public budget. This is the extreme opposite to an efficient long-term market allocation of resources. The important question is what the prerequisites are for an efficient market allocation of funds. Do the adverse allocation effects associated with i.e. the tax and subsidy schemes make less resources available for other better investments?

1.5 The Small Innovator and the Equity Market

We have argued so far that no efficiency reasons can be advocated for large scale public subsidy interventions in stagnating businesses. At the same time such interventions before they took place, have practically always been presented either as ventures for the future or attempts to give an obsolete company a new future. Let us reverse the argument and ask whether there is any need for public support of high technology investments. Does the small innovator need any new financial help from the public sector or rather, is there any evidence to show that new technologies have not succeeded because of lack of finance. Hence, is there any need for new institutions in the finance markets to cater for the high technology companies.

One characteristic of new technology investments is their high risk content. Hence such investments to a large extent tend to be internally financed within large companies. For any outside supplier of funds to be interested he will have to be both well informed and be offered the opportunity of a share in the possibly large profits, since he will run a higher risk than normal of not getting his money back if the project

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*) Indeed that seems to be a likely outcome. See Eliasson & Lindberg (1981).

**) Amounting to almost 16 percent of value added or at least twice the money spent on R&D in industry in 1979. See Carlsson-Bergholm-Lindberg (1981).

turns out a loser. The typical involvement then becomes equity participation or the outside financier has to have an objective function that identifies with a larger collective interest. This can be the case for the government that is supposed to see to the interests of the entire nation, or for a large commercial bank serving the interests of a group of companies, with a large joint ownership, or a large business organization, where all financial arrangements are internal. A normal credit contract on the other side would have to carry a very high interest rate to cover the insurance premium for large possible losses. The creation of limited liability, joint stock companies in the 19th century was also characterized as a major "technological" innovation that made it possible to pool large resources for risk ventures in a fashion not possible before. Similarly, an unlimited number of case histories can be told about a "financier" (a privately wealthy person or a company) entering into an equity partnership with an inventor or a small innovative company that needed an enlarged capital base. During the last 10-15 years a number of publicly supported institutions have been created in the Swedish credit market all with the explicit objective of catering for the needs of particular investors engaged in high risk activities. Contrary to our conclusions above, they have not typically been of the equity participation type but rather extend regular types of credits at normal rates of interest. In effect then credits have been given at a subsidized price.

The question asked was, do a number of new technologies, products or production processes lie unexplored because of lack of finance. The capitalist's answer would be that in a sufficiently "pluralistic" market economy, the culture of which places a premium on material wealth, some institution or person would soon pick up the idea or new institutions would automatically be created to do it for pure profit reasons. If this does not happen the presumtion is that the "idea" wasn't really that good to begin with by commercial criteria. Besides risk content there are only two exceptions to consider. The first refers to size. Some projects may be so large that there exists no market solution. It is, however, difficult to give good and obvious examples that provide a good case for government intervention; Nuclear Power, the Space Shuttle and the Concorde are all cases where the economic rationale behind needs further clarification. The second has to do with the possibilities of establishing a temporary monopoly around the innovation. If the knowledge cannot be protected by patent, secrecy or rapid, continuous quality upgrading the incentives to incur development costs do not exist. Such externalities have normally been catered for by the creation of appropriate institutions; schools, universities or other research institutions, special R&D firms etc. The small scale venture capital institutions working directly with creative individuals as in Californian electronics industries during the last few years are a good example of a spontaneous market response for a financial need, expressed in terms of grand payoffs for the successful.

At least three conclusions follow from the above theoretical discussion. First, large firms that have been successful in the past possess the necessary finance of the desired quality (risk capital). However, large firms may not in all respects be the most efficient managers of new technologies. Second, small firms may be better organized to manage the first innovative stages of new technologies. They, however, often lack the necessary amount and quality of finance and management expertize, which is a form of technological competence.Third, technology in the context of a modern business company is a broader concept than processes and products. An important part of the technology of successful firms, for instance, has to do with marketing and distribution.

We conclude this paper with two case presentations of how new technologies were financed:

1. A large, high technology venture in a large company (AXE in LM Ericsson),
2. The financing of a new product in a large firm where technical sophistication is not the main innovative element (the new Volvo model).

2. THE FINANCING OF NEW TECHNOLOGICAL INVESTMENTS IN TWO LARGE COMPANIES

2.1. Introduction

Telephone exchanges at LM Ericsson and passenger cars at Volvo represent the two cases. The choice was motivated by:

o Both cases represent large scale investments, in one case in a very sophisticated technology.

o Product development in both firms is characterized as major product generation shifts, intermittently straining the financial resources of the companies.

o Both companies are multinationals. They are very large by Swedish standards but quite small in an international comparison when "financial size" is compared.

Much of the technology and industrial policy discussion in Sweden has centered around financing issues and the problems arising from inadequate funding of R&D of various sorts. The development of large scale technology in international competition has been at the tune of soaring R&D costs and has been accompanied by a downward trend in profitability in industry. The following case reports concentrate on the funding of R&D work. The reader should keep in mind, however, that this is only part of the overall financing required to support a growing company. Figure 2 summarizes the chronology of the cases.

2.2 The Development of a New Generation of Passenger Cars at Volvo

In Febr. 1982 Volvo introduced a new generation of passenger cars. A new generation has so far been launched each 10-15 years preceded by "terrible torment, not the least financially". While the new generation of passenger cars in the 50's, the Amazon generation, took around 3 years to develop at the R&D cost of 50 MSEK (=Million Swedish Crowns) the new generation in the 80's will have a R&D time of 4-5 years and the R&D cost will exceed 2000 MSEK. The annual R&D cost for passenger cars amounted to some 5% of the corresponding sales in 1978. In the years to come it is, however, estimated to rise to 10%, including tooling. (See Table 1).

Factors behind the increasing R&D costs are the cumulative effects of customer and governmental demands on safety, comfort, environmental protection, fuel economy and general performance. Also the need to control the rising costs in production increasingly require improvements in tooling. The tooling costs, amounting to 25-30% of R&D costs, have grown exponentially.

The intermittent product generations amplify the financial problems of rising R&D costs. They are typical for passenger cars and are also becoming increasingly pronounced. The development of trucks on the other hand is more gradual, although there is in this case a trend towards the creation of model generations as well. Both technical and market factors lie behind the formation of product generations. Technically the so called packaging of the components in the system of a passenger car has become very efficient and the geometry of the self-supporting body makes gradual changes difficult and uneconomical. *) Thus a polarized pattern of introducing minor changes in yearly models and major changes in connection with generation shifts are favored as economical. Technical solutions to smooth out generation changes are not explored.

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*) This is also true in other engineering industries, where the major productivity improvements in production are simultaneous with new product designs. Cf Eliasson (1980).

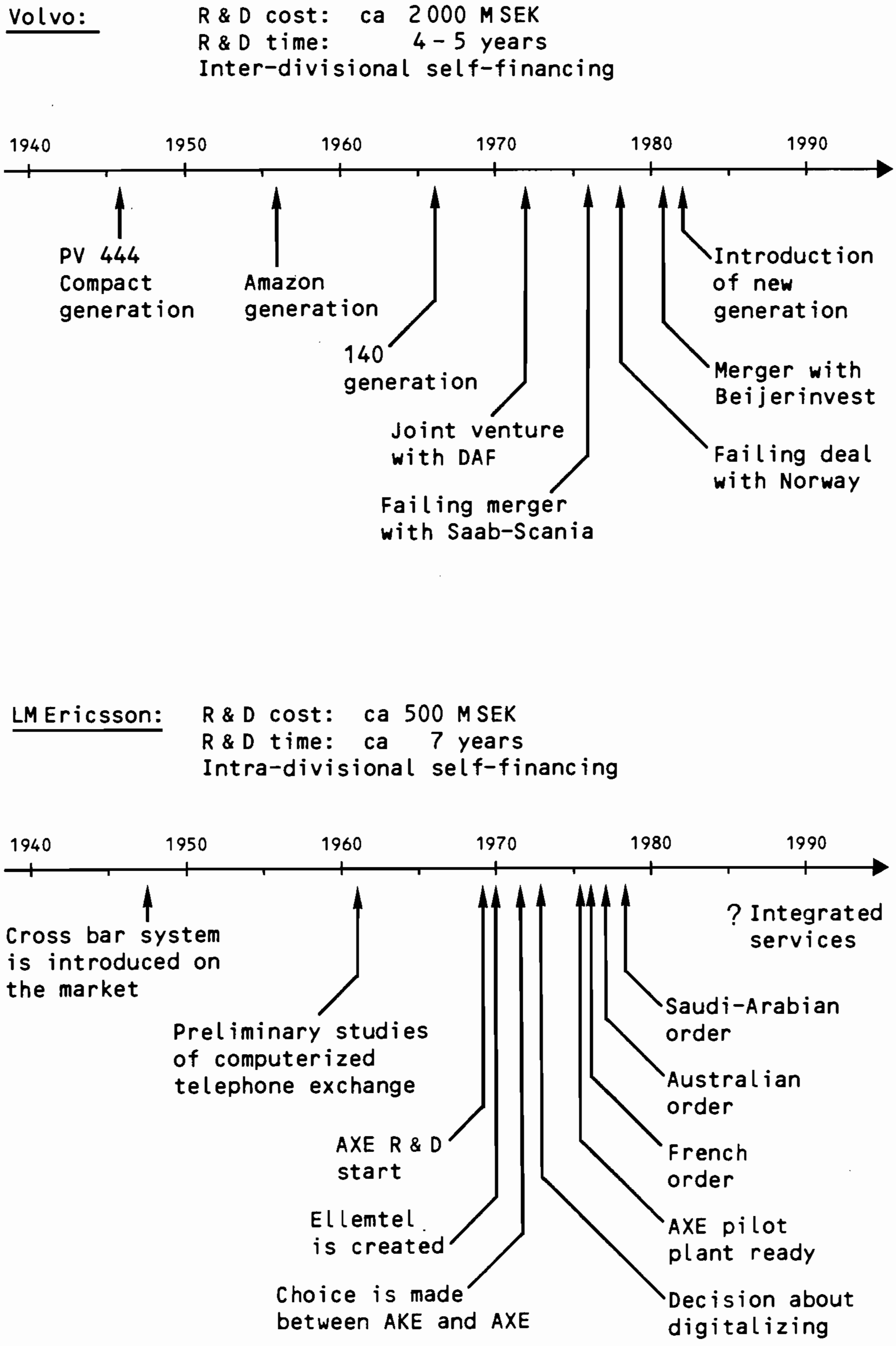

Figure 2

Chronology of the Volvo and LM Ericsson cases

Scale economies in the serial production of passenger cars are considered dominant, although the realization of such scale economies is not totally dependent on the formation of product generations at the level of the entire system of a passenger car. Finally some market factors also favor intermittent formation of product generations. Customers demand substantial renewals of models after a while and it is also very risky in a basically conservative mass consumer market to deviate markedly from the behavior of established competitors. Even though the marketability of a product may be enhanced by intermittent model generation formation, some gradual adjustments of model designs seem possible at the image level, opening up possibilities to smooth out R&D costs. Nevertheless Volvo management believes that the pattern of generation formation will prevail in the decades to come. The exponential trend of rising R&D costs, however, is believed to be curbed.

Given the patterns of rising R&D costs and product generation formation and also the 50% sales dependence of Volvo on its passenger car business, -what are the financial problems for Volvo? Three dimensions of the financing problem stand out. Development (investment) costs are considerable. The bulk of the financing has to do with tooling, hardware investments and sales finance and hence applies at a fairly late stage in the development cycle. The early R&D stages (the gestation period) are becoming longer and the indirect consequences of a less successful new product generation for the entire company are increasing. Hence, total risks tend to increase as well. The awareness of these problems has been acute in Volvo and the history of Volvo from the mid 70's shows a variety of spectacular initiatives, many of which have been motivated by the need to spread risks and reduce the heavy dependance on passenger cars. Several important steps may be distinguished in this context.

A giant merger with Saab-Scania, the other Swedish automobile manufacturer, was proposed in 1977 but never realized, mainly due to managerial resistance at top level in Saab-Scania. This merger was never considered a direct solution to the financing problem of a new model. Rather benefits of rationalization and the pooling of resources were sought.

Secondly, some years after the aborted attempt to merge with Saab-Scania, a spectacular move was announced in May 1979. Volvo announced intentions to enter a joint venture with Norway. In exchange for Volvo shares and industrial know-how, Volvo would get access to Norwegian oil money as well as Norwegian oil business opportunities. Although "the Norway deal" according to the official discussion was a solution to the financing of the new automobile the joint venture according to Volvo management was rather sought in order to give Volvo another risk profile. After heated, public discussions, not lacking in drama, the proposed joint venture was finally blocked by a group of main share holders in Volvo.

Table 1
Economic Data for LM Ericsson and Volvo

	LM Ericsson	Volvo
Sales 1975 (MSEK)	7 240	13 692
Sales 1980 (MSEK)	12 174	23 803
Growth (Sales 1980/Sales 1975)	1.68	1.74
Average annual growth 1975-80	10.9%	11.7%
Internationalization 1)	0.58	0.28
Diversification 2)	0.64	0.50
Pre-tax profit after depreciation 1980 (MSEK)	935	1 007
- as % of sales (profit margin)	7.7%	4.2%
Cumulated profit 1976-80 as % of cumulated sales	7.5%	4.0%
Main Product area	Telephone and telex stations	Passenger cars
Sales in main product area (MSEK)	4 442	11 980
Sales in domestic market (Sweden)	22%	25%
R&D cost 1980 (MSEK)	1 013	n.a.3
-as % of sales	8%	n.a.
- as % of investments in machinery and equipment	141%	n.a.
R&D cost 1975 (MSEK)	510	n.a.
- as % of sales	7%	
- as % of investment in machinery and equipment	78%	
Average annual growth of R&D cost 1975-80	14.7%	n.a.
Capital turnover 1976 4)	0.7	1.06
Capital turnover 1980	0.7	1.08

1. Employees abroad/total number of employees.
2. Sales outside largest product area/total sales.
3. R&D for passenger cars amounted to ca 600 MSEK or 5% of corresponding sales in 1978.
4. Total sales/total assets (according to the balance sheet).

Source: Annual reports.

Thirdly, a new giant merger between Volvo and a large Swedish conglomerate, Beijerinvest, was announced in late 1980. This merger will again give Volvo its desired new risk profile and new business opportunities. The prospects for financing the new automobile generation have also improved. The Swedish stock market seems to have recovered and stock investors have displayed a trust in the Beijerinvest management that it did not show to Volvo management alone. During the 70's Volvo turned to the stock market several times for new capital, including special direct emissions to the public complementary pension (the AP) funds. But the gloomy prospects of investing in stocks in automobile business, especially after the oil crisis and the general recession in industry, made the Swedish stock market appear very reluctant vis-à-vis Volvo. The devaluation of the Volvo share has also been an inhibiting factor in trying out foreign stock markets. Apart from legal obstacles, the additional risk for take overs was considered too great.

The credit rating of Volvo has increased internationally. Because of its size and its introduction on the London stock market, Volvo now has good opportunities to borrow abroad. Another factor improving the financing situation is the improvement in capital turnover (see Table 1). An increase of 0.1 in capital turnover would reduce financing requirements by about 2000 MSEK, which is roughly the required total amount for developing the new automobile generation. Finally and foremost the heavy vehicle sector (trucks, buses) has generated a steady cash flow during the 70's, amounting to roughly one billion SEK in 1980. *) It now seems as if the new automobile model generation can be self-financed through profits from heavy vehicles. These in turn are not typical "cash cows" in the sense that product and market development has stagnated. They are rather outstanding profit generators subjected to continued development. In this way the problem with financing the new generation seems to be solved in the traditional way through internal profit generation. The question is rather why the cash flows are not planned to be reinvested in heavy vehicles instead. Incidentally, the new organizational design in conjunction with the Beijerinvest merger has put the passenger car division on a joint stock limited liability basis. The opportunity will exist to introduce the division on the stock exchange as a separate corporate entity. In connection with transforming the passenger car division into a joint stock company, French state owned Renault bought in 1979 a 10% minority interest in the Volvo Passenger Car company with option of another 10%. (Together with Peugeot and Renault Volvo had back in 1971 formed a joint company for development and production of passenger car engines.) Recently the Renault minority share has passed the 10% level. This means that the Volvo passenger cars will no longer be eligible for taxfree intra-group contributions to cover losses, e.g contributions from the highly profitable truck division. All in all Volvo has created links with several financially strong partners - Renault, the Dutch state, which in 1980 owned 45% in a joint company with Volvo for the Dutch car DAF, and the Swedish public complementary pension fund, which is the largest shareholder in Volvo with more than 5% of the Volvo shares in 1979.

*) Net after tax profits from heavy vehicles in fact amounted to 1010 MSEK in 1980 while, the passenger car division showed a loss of 195 MSEK. The Volvo Group as a whole reported a 1007 MSEK profit.

2.3 The Development of the Telephone Exchange System AXE at LM Ericsson

Beginnings and ends of large R&D projects are difficult to pinpoint but with reasonable definitions the development of the public telephone exchange system AXE at LM Ericsson took place between 1969 and 1976. The pure R&D cost amounted to roughly 500 MSEK. The system clearly marked the transition of LM Ericsson from an electro-mechanical to an electronic systems producer. The earlier product generation, the so called cross bar system, had been developed during and after World War II and was introduced in the market in the late 1940's with a subsequent market expansion in the 50's and 60's.

The history of AXE does not involve financial problems and spectacular responses to them of the same magnitude as has been the case for the new passenger car generation in Volvo. However, the history of AXE with respect to technological and market factors is interesting. In the early 1960's pre-studies of new telephone exchanges were initiated with the primary focus on computerization. The computer people in the 60's had little understanding of the special application of computers in telecommunications and the LM Ericsson people, consisting of "telephone people" and newly graduated engineers, had but minor contact with the established computer world. At the same time top management in LM Ericsson were not acquainted with electronics and computer technology. The result was that most of the work on computerization was self-development, often along unconventional lines. Competence in computer technology was built up internally during the 60's, especially about computer architecture, systems reliability, multi-processing and structured programming. The latter experience then paved the way for systems modularization, an important feature of the AXE system. Thus the transition into a new technology for an old application was achieved through self-development, creating design concepts which were new also to the new technology.

Around 1970 there were many internal discussions whether to continue development along the lines of a centralized telephone exchange, AKE, or develop a new system, AXE, based on modularized software and reed selectors. For a few years AXE and AKE were developed in parallel, although AKE development became more geared towards market adaptation. A strategic decision was taken in the early 1970's about full scale development of AXE. At that time Ellemtel had been created, a jointly (50/50) owned company between LM Ericsson and its Swedish customer, the state telephone administration Televerket. This company was to do the development work of the new telephone exchange. Economic calculations for AKE and AXE were presented, giving estimates of some 100 man years for AKE, and some 1000 man years for AXE, with several years longer R&D time. However, there was almost a tie between AKE and AXE. The managing director of LM Ericsson then asked people at Ellemtel which way they believed the economically optimal technology would go and their choice was the technically more advanced system, AXE, - a likely choice by development people.

The first pilot plant of AXE was ready 1976. Then things have happened rapidly. Technologically the system has been updated in several steps. An important step has been to digitalize the system, which represents a second AXE-generation. The coming transition from analog to digital voice transmission was recognized and decided upon in 1973-74 and a fully digitalized version was introduced in 1978-79. A third AXE-generation is roughly scheduled for the mid 1980's, providing integrated services in the transmission of data, speech, texts, and pictures.

The market development of AXE involves some spectacular events. The market breakthrough, apart from the Swedish market, came when the competent Australian telephone administration decided upon AXE in 1977. France decided upon AXE in 1976, but in this case LM Ericsson had to give up majority ownership of its French subsidiary. Nationalistic pressures have forced LM Ericsson to sell out stock in other foreign subsidiaries as well in order to get contracts. Thus not only products are sold but also parts of the LM Ericsson international organization, - not as a response to financial problems but as a response to the increased bargaining leverage of nation states and their strive for technology sharing.

The most important market success for AXE was the huge contract signed with Saudi Arabia in 1978 and jointly won together with Philips in fierce competition, among others with the old time competitor to LM Ericsson, ITT. The contract totalled about 15000 MSEK with roughly a third falling on each of LM Ericsson and Philips managing the installation and Bell Canada managing operations and education for 5 years. About 2000 MSEK of the LM Ericsson part will be exported from Sweden. This contract has firmly established LM Ericsson as the technological leader in its field. The contract also proves and improves the company's organizational capability and at the same time strengthens the financial basis. The market development has been rapid since 1978. By 1980 the AXE-system has been introduced in 25 countries. The substitution of old systems on the market has proceeded much faster than initially anticipated by LM Ericsson, resulting in large stocks of parts during some periods for the old systems and strains on the ability to convert the production and marketing organization to the new product and production technologies.

On the financial sides, a strong trend towards increasing R&D costs in telecommunication industry is seen. (However, one has to keep in mind that companies have an interest in showing high R&D costs.) About 80-85% of R&D costs are costs related to personnel and software development like programming. However, there is also a trend towards incorporating software functions in the hardware components. In order to meet the risk of technological dependence, especially on US component manufacturers, LM Ericsson may in the long run have to become more self-supporting on the component side, in turn adding more R&D costs. A main factor in favor of integration backwards in the short run is the risk of disseminating knowledge to suppliers.

The formation of product generations is not so pronounced in tele-communications as in passenger cars. Rather, there are technological substitutes at the component and subsystem levels. Even identical systems are not mass produced. Computerization of course meant a pronounced generation shift but generation shifts tend to be smoothed out, at least for LM Ericsson. This is due to the modular design of AXE, permitting the introduction of new technologies without having to change the whole system. Another factor behind the smoothing out of generation shifts, as claimed by an LM Ericsson representative, is the improvements in R&D decision making, based on technological and market forecasts. Naturally, new products will have to be introduced in the future and the creation of product generations is still likely to take place in the future, not the least because of marketability reasons.

The development of AXE has essentially been self-financed through profits at the divisional level of telephone exchanges. Until the early 1960's the technology development part of R&D (in contrast to product development) was centralized in LM Ericsson and financed through taxation of the different businesses according to a percentage of turnover. When divisionalization was introduced in the early 1960's each division had to carry its own R&D costs. A certain corporate R&D fund has also existed but it has not been of any importance for the financing of AXE. The R&D costs in Ellemtel have been carried to roughly 75% by LM Ericsson. Televerket has had no financing part of development and market adaptation of AXE since 1976. The most important financing factor is the traditionally high profitability in telecommunications industry. LM Ericsson is a typically specialized company with small possibilities to reallocate capital between different businesses. Also the company is highly internationalized and sells its products to a few, very competent national customers. This involves political risks. The financing side of the AXE development hence has a very different quality than was the case for Volvo.

However, LM Ericsson is likely to experience financial problems ahead. Not only R&D costs rise but the demands on customer credits are also increasing. At the same time the unanticipated rapid transition in the market to the new system results in large stocks of old products, tying up working capital (capital turnover is only 0.7, see Table 1). Finally and foremost the company is now diversifying into office automation and business communication, which will require much capital. At the same time profit margins in the traditional telecommunication business are shrinking.

3. COMPARISONS AND CONCLUSIONS

The cases of Volvo and LM Ericsson may seem as success stories with no problems of finance at all. LM Ericsson has managed to develop and finance a new generation of telephone exchanges. Telephone exchanges turned out to be one of the most successful of Swedish products in international trade since World War II, heavy trucks being another. Volvo has succeded in transforming itself from a specialized passenger car company into a higly successful truck manufacturer as well. High profits from truck manufacturing have bolstered the financial consequences both of a new product failure (the small size DAF model) and of the period of sagging automobile demand of the late 70ies.

R&D for the new passenger car model have required roughly the profits from the heavy vehicle sector during 2 years. Self-financing was relied upon in LM Ericsson but not possible in Volvo, which was forced to take several initiatives in the direction of shared financing and joint ventures.

Both companies have engaged themselves to a minor extent in joint development ventures to spread large R&D costs; LM Ericsson with its domestic customer Televerket in Ellemtel and Volvo with a competitor, Renault, to develop a new engine. Similarly, Saab-Scania (the other Swedish car company and the once proposed partner to Volvo) has reached an agreement with Lancia (Fiat) to jointly develop the next generation of passenger cars. Joint venturism is generally growing among car manufacturers as a response to a rapid upscaling of new product development investments.

Both Volvo and LM Ericsson dependend to some 50% of sales on passenger cars and telephone exchanges respectively. The acute problem is to lower this dependence through diversification; Volvo into energy and LM Ericsson into office computers and business communication systems. This has been the major force behind the Volvo moves since 1975. The major strategy for these diversifications in both cases seem to be acquisitions.

The case descriptions of Volvo and LM Ericsson do not support the idea that in the development of new high technology product generations, financing is the major problem, calling for government intervention, joint ventures, or new financial institutions. The problems are rather what would happen if the high risk venture had failed and at what stage of the development program that the whole burden of risk is taken on.

In a sense the kind and the availability of financing may force a company into a less than optimal decision making situation, that rather increases the degree of overall risktaking. Furthermore a good portion of luck is characteristic of most successful companies or at least an aptitude to spot and exploit lucky circumstances. But if the absence of a steady flow of internal finance, or a cumbersome procedure to obtain external finance makes the firm too cautious and slow in its development program and in its willingness to take on risks it may loose out altogether in the long run.

Neither of the companies consistently handle the development of new generations as investments. One aspect of this mentioned in the interviews is that decision making has typically been piece-meal, let be that strategic decisions about what business areas to operate in and so on surround the decision making concerning new product generations. This is not so because of lack of risk awareness but because of risk awareness. The risks involved, both at company level and the level of individual top managers, are so large that one prefers to move cautiously, one step at the time. In a sense this also creates a possibility to diffuse potential blame for a failure. On the surface of the documented part of decisions, there are detailed analyses and plans for rational decisions but the piece-meal, intuitive nature of decisions are admitted behind the scenes in retrospect. The technological pioneering and market timing of AXE may seem skilful but there were small margins between success and failure. Too much caution and a wait and see attitude because of the financial risks involved might be all that is needed for a clever or lucky competitor to take the lead and cream off the market. It is not likely that LM Ericsson would have gone bankrupt or would have become technologically obsolete, given its good communication channels with both the science and technology community and the advanced customers, but the company could have fallen behind for a decade or so and lose its ability to self-finance future development. The risks involved in a failure of the new passenger car in Volvo are of a similar nature. The technical and market possibilites to smooth out future generation shifts are moreover limited, at least in Volvo, and the chances for a slowing down of growth in R&D costs are slim.

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ONE-WAY VERSUS TWO-WAY VIDEOTEX

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1. INTRODUCTION

The basic idea of videotex is to add sufficient electronics to TV sets so that they can be used not only for receiving TV programs but also as terminals of a (potentially computer-supported) information system. Around the end of the 1970s videotex systems came along in two varieties: as *broadcast* or *one-way* (1W) systems and as *interactive* or *two-way* (2W) systems. In the first case, a set of information *pages ("frames")*, each identified by a number, is available. The user can select which of the information pages (usually containing textual information) he wants to look at, usually by keying in the number of the desired page using his TV remote-control unit, TV set. In the second case, the user can not only retrieve information pages, but can also send information which can be used for ordering, booking, communication, and many other interactive applications.

One-way videotex can be of two types. The narrow-band version (1WN videotex) is the older, "classical" version -- first introduced as *Ceefax* by the BBC and *Oracle* by the IBA in the UK. In the same category, Austria's *Teletext* was the first nationwide 1WN videotex service and has now over 100,000 participants. Other countries have since introduced 1WN videotex on a nationwide scale, such as West Germany's *Videotext*. In all these 1WN videotex systems some few hundred information pages are sent on a rotating basis on the same channel and are simultaneously mixed with an ordinary TV program (using the vertical and horizontal blanking intervals for transmission), which has to be "demixed" by a so-called teletext decoder to prepare the relating flow of information frames for selection. In this fashion less than 10 frames of information can be transmitted per second. Hence, to avoid annoyingly long waiting times for a page specified by a user, only a moderate number of frames (some hundred) can be sent before retransmission has to start again.

The second version of 1W videotex uses a fully "dedicated" TV channel, usually available via cable TV (CATV) or, in countries with few TV programs or empty channels, one could imagine a separate broadcast TV channel devoted to teletext. The basic idea of this wide-band (1WW) videotex is similar to that of 1WN except that much larger quantities of information can be sent within the same amount of time if a more powerful, faster, and more sophisticated teletext decoder is used. On average, some 50,000 frames can be offered within a few seconds.

In contrast to the 1W videotex, in the two-way (2W) version the user has a separate channel for communicating in the other direction. The most common implementation of this idea is to use switched public telephone lines for communication in both directions. Thus the TV set acts as simple computer terminal which is hooked up -- via a telephone dialing line -- to the computer of the videotex center (which in turn may act as gateway to other "*external*" or "*third-party*" computers to create a videotex network or, as they call it in Germany, *Rechnerverbund*). Although the TV set as videotex terminal has all of the functions of a computer terminal, much of this potential (but in varying degrees), is not used in current videotex systems. This is partially due to very rudimentary "keyboards" (often only the numeric keypad TV remote-control unit) available to the user; to the lack of software in the videotex centers; to the rudimentary state of the videotex network (if available at all) and to the "primitiveness" of the terminal. However, even in the simplest variants, the feedback option of 2W videotex does offer many possibilities not available in 1W systems.

We will discuss some further special aspects of videotex systems required for comparing 1W and 2W systems in the sections to follow, but refer to studies such as [6], [15] and [18] for a broader overview. We close this section by noting that other terminal implementations of both 1W and 2W videotex systems are also feasible and are or have been experimented-with: e.g., using a full radio channel for 1W videotex, using CATV with feedback channel for 2W videotex, or both using CATV (in one direction) and telephones (in the other) for 2W videotex.

2. CURRENT AND FUTURE VIDEOTEX TERMINAL TECHNOLOGY

The most widely used types of videotex today are those based on early developments in UK (*Ceefax*, *Oracle* and *Prestel*); these make use of very simple (i.e. "dumb") terminals with very little local processing and storage and (in the simplest version) only numeric keypads. In contrast with these terminals and some of their planned successors in Switzerland, Holland, and West Germany, for example, other countries have decided to develop terminals with more local processing capability (Canada and the US), and alphanumeric keypads as standard input devices (France). Furthermore, some existing personal computers (such as the Apple II), have been made "videotex compatible" by adding appropriate interface cards to the basic system.

With the falling price of integrated circuits we expect that future videotex terminals will tend to have more and more "intelligence" and alphanumeric keyboards at ever-decreasing prices. Such local "intelligence" (which might put the future videotex terminal, or a version of it, somewhere between a videotex terminal and a personal computer of today) will make the use of videotex easier, will allow certain amount of decentralization and will open up the possibility for applications such as using telesoftware [13]. The availability of local storage and intelligence will also be particularly useful in connection with 1W videotex, especially in the wide-band version. (See Sections 3 and 4).

It is becoming increasingly evident that future videotex terminals will allow external attachments such as to tape recorders (already in use in Holland, for instance) and printers, to enable hard copies of frames of interest to be printed. Although one cannot expect that all ordinary households will be equipped with printers in the foreseeable future, "semi-local" printing devices (such as one printer for a whole apartment building) could become a reality within the 1980s and could increase the impact of videotex considerably. In addition, cheap printers for personal computers are already available. In the UK, for example, Sinclair offers to its XZ81 computer a small matrix printer for less than £ 50.

3. CURRENT AND FUTURE 1WN (ONE-WAY NARROW BAND) VIDEOTEX

Due to the fact that only some 100 frames (corresponding to less than ten newspaper pages) can be sent in the usual 1WN videotex systems within some 20 seconds, the applicability of 1WN videotex appears to be severely limited. Typically, the 100 pages of information sent in the early days of the Austrian service (early 1980) were at most moderately useful. In a small experiment, one of the authors found that after some initial high usage due to the novelty of the service, usage dropped to less than once per user per month. An analysis of the reasons for such very limited usage has revealed two major factors: one is limited (and possibly "wrong") information presented, and the other is the cumbersome access procedure. To find a specific piece of information a number of index pages have to be looked up first, each look-up lasting between 0-20 seconds (which tend to seem like an eternity!).

Much experimenting with the type of material and how to present it has improved 1WN videotex remarkably. The authors feel that further improvements along the same lines and using some new ideas suggested below will make it an interesting and, because of the favorable cost-benefit ratio, a permanent feature of TV.

Some of the improvements of 1W videotex which have been implemented in a number of countries such as Austria are as follows.

Rather than sending all pages with the same frequency, one new idea is to send them at widely different frequencies, and this can be used in two ways. One is to send survey and index pages more frequently to allow quick access to routing information, as is done in the West German system, for example. The other is to group pages (which one can assume will be accessed by the user mostly either not at all or else all of them) into "magazines" where the pages are transmitted at, say, 20 second intervals. Thus, some 15 pages of international news could be handled in this fashion: it is possible that users will be interested in glancing through all of those pages. At present, this technique is used by almost all teletext operators. By typing one frame number the user could be presented with 15 pages over a 5-minute period, allowing relaxed reading of all the news presented. The systematic application of the "magazine" idea enables some 1000 pages of information to be accommodated in the (roughly) 100 time-slots available, thus increasing the usefulness of 1WN videotex tremendously.

There are, however, some drawbacks to the "magazine" technique. One is that whenever a specific item of information is required from a given magazine one has to wait -- sometimes five minutes (!) -- until the information appears on the screen. No quick searching is possible, as one can do with a newspaper. Furthermore, the viewing rhythm is set for every magazine to allow only "mechanical" reading of information, without any slowing down or speeding up of the frames. This again is one of the most important advantages of traditional printing media. It is possible to "freeze" on the TV screen any teletext picture, to allow more time to be spent on reading and digesting the content of the frame, but when switching back to the normal mode of operation several other frames in the sequence were missed in the meantime, and one has to wait -- sometimes another five minutes -- until the next desired page of information appears on the screen.

In our observation of the Austrian system we found two extremely long magazines: one *Lesen statt hoeren* (Reading instead of hearing) for the handicapped, with 18 frames of information linked to one magazine, and one with 20 frames containing list of the Austrian ski champions at Olimpic games and World Championships -- a subject which one would expect that in Austria at least would deserve a separate page each. The second problem is with the indexing of pages contained in the magazines. Due to lack of space at present only the title of the magazine is contained in the index. However, the pages in some magazines are rather different in nature and certainly deserve central indexing, otherwise they are lost to new or inexperienced readers. But if this information were contained in a general index, there would a the problem of access, because first the magazine has to be addressed but then the only way to get the information is to wait. Thus no direct access to the information is possible. This could be improved in principle by introducing intelligent decoders for 1WN videotex system.

Regarding the content of information, we have made comparisons between the Austrian *Teletext*, the West German *Videotext*, and the experimental Swiss *Teletext* systems. The information broadcast by the Swiss system is compiled by a consortium of major Swiss newspapers and publishers, with the clear aim of producing an "electronic newspaper" with news, culture -- even poetry -- art, reviews, etc., although our personal impression is that the use of this medium for most of these purposes is of limited value. The West German *Videotext* has a separate teletext editorial office in West Berlin run by the radio and TV companies. The main trend there is to provide a tool which basically supplements local radio and TV stations, such as by providing details of future TV and radio programs. For example, they display frames on the detailed content of the major evening news programs *Tagesschau* and *Heute* some two hours before they are broadcast. In principle, no newspaper can compete with such a service, and teletext is also not duplicating information available from another medium. Furthermore, the "subtitling" program (the importance of which will be explained below) is also quite advanced. The Austrian *Teletext* program is a "mixture" of the Swiss and the West German system, and is run by the national radio and TV authority of Austria, ORF. In addition to the above services the ORF teletext offers an interesting on-line service on four pages on the status of arrivals and departures of all flights to and from Vienna airport, Schwechat, with only a 3-5 minute delay in the latest information from the Schwechat control tower. According to ORF data the "main headlines" on page 171 are brought up to date 50 times per day and the ORF team updates daily 1000 frames of information. According to a sample taken on January 29, 1982 at 4 p.m. the Austrian system broadcast 82 different pages, identifiable with separate page numbers. Out of these, 53 frames were repeated in each broadcast cycle, and 29 carried a total of 150 frames in "magazine" fashion – as will be described in greater length below. The ORF service is subdivided in five major subject categories called "registers":

Reg. 1. (*Service Aktuell*) contains general daily information of broad interest such as weather, exchange rates, air traffic, major events, traffic conditions, snow conditions, etc. In total, 21 pages (eight in "fixed" and 15 in "magazine" mode containing 59 frames).

Reg. 2. (*Lebenshilfe*) contains information on emergency telephone numbers for diverse cases (hospital, pharmacies, etc.), consumer advice, general information for the handicapped (27 frames!) and a language training course (nine frames). A total of 10 pages (three "fixed" and seven in "magazine" mode with 48 frames).

Reg. 3. (*ORF- Program*) contains information on future radio and TV programs and a separate frame (No. 150) for carrying subtitles for subtitled programs. In total 17 pages of information are broadcast, 14 in "fixed" and three in "magazine" mode with seven frames.

Reg. 4. (*Unterhaltung*) contains five frames of information in "magazine" fashion with eight frames with entertainment such as a chess corner and a zodiac.

Reg. 5. (*Nachrichten*) contains news frames on national and international news, sport, the economy, etc. In total 21 pages, 20 of which with "fixed" information and one page with 20 (!) frames on all Austrian ski champions in "magazine" mode.

In addition, there are some further information frames which do not fall into the above categories; some of them are "service" frames of teletext, such as index pages or page 199 which contains eight frames of news in English taken from the BBC's *Ceefax*, London. Thus, as mentioned above, the Austrian teletext system is a mixture of different services on 100 frames.

In the early days of videotex (1W and 2W it was considered a no-no to "overload" pages by putting too much on them) the readability of pages was deemed to be crucially important [1]. Like in many situations such a dogmatic view has turned out to be wrong: although it is true that those pages which are supposed to be read (i.e., those with "actual information") should be readable and thus not overloaded, pages which are not to be read but just to be glanced at (i.e., routing pages) could and should contain densely packed information to avoid too many routing accesses. This philosophy of concentrating as much routing information as possible onto a page has improved the usability of videotex considerably. This becomes apparent by examining the alphabetic index of Austria's 1W or 2W videotex, or of Meyer's encyclopedia in the 2W videotex system in West Germany.

Another important lesson which is gradually being learned in connection with 1WN videotex is that, as mentioned earlier, it should not be used as "electronic newspaper" (reading of lengthy material on a TV is not satisfactory due to the poor quality and the lack of portability of the display; see [5], [6]) but should be used for up-to-date information of wide interest, for special interest groups who have to rely more on reading than other groups (such as deaf) and, in particular, in connection with ordinary TV programs. The use if 1WN videotex for subtitling (as is gradually being introduced in a number of countries) is an ideal example. Although subtitling is currently only used in programs for the deaf it is feasible, and will hopefully be pursued in the future, to use it for translating interviews: the interview would carry the speakers' and the interviewers' words in a foreign language on the audio channel, and the subtitle would condense the translation in the viewers' language.

1WN videotex should also prove helpful for all kinds of semi-emergency information which would presumably interest such a wide segment of the population as to overload any two-way videotex service, should it be offered by them.

A number of major improvements in 1WN videotex will be made possible as terminal technology develops. As was pointed out in Section 2, it is quite realistic to assume that intelligent terminals with local storage capabilities of 20-50 pages will become widely available within the next 10 years. Such terminals will upgrade 1WN videotex in at least two ways: they will allow alphabetic searching and the local storage of frames. For example, a user would be able to type in an arbitrary alphabetic keyword which would be searched for by the terminal's microprocessor (either by index pages provided, or else by searching through all the pages being received), finally resulting in the display of all frames relevant to the specific keyword. Another application of such a terminal is to allow the user to type in the page number of a magazine (in the sense mentioned above) which is then fetched (and kept up-to-date) for later convenient and fast retrieval. The use of such terminals might permit the expansion of magazines to even more pages, giving 1WN videotex the potential of an attractive 2000-4000 pages of up-to-date information.

Another way of increasing the information capacity is reported by Tydeman [2], who mentions that in some of the US teletext trials different magazines are put on the systems at different, predefined times. We feel that 1WN videotex will also gain further importance if it is combined with 2W videotex, as will be explained in Section 6.

One of the most significant improvements of 1WN videotex will, however, be made by attaching printers to videotex terminals. Although the piece of such printers will drop to well below US $200-300 in the near future, we believe that the price is not of critical importance. In an apartment buildings, for example, a printer could be shared (as is sometimes done with laundry machines) between dozens of apartments, making even sophisticated printers feasible. Similarly, coin-operated printers could be made available in public places (as photocopying equipment is today), etc. The availability of such printers will make facsimile newspapers, distributed via 1WN videotex, a very attractive alternative, solving the increasingly tedious and expensive problem of newspaper delivery. With new terminal technology [7,8,9] even the delivery of reasonable quality pictures (requiring about ten times longer for transmission than ordinary text frames) is possible.

The viability of the above notion is demonstrated by the following calculation based on the situation in Austria: suppose 1WN videotex is used for transmission of facsimile newspapers during the off-time of Austrian TV, e.g. for the five hours 1:00-6:00 a.m. At four pages per second, over 70,000 pages can be transmitted. Assuming 70 participating newspapers, 1000 frames (equivalent to more than 40 large newspaper pages and 40 pictures) are available for each newspaper, clearly more than ample room. Observe that a printer which is supposed to print more than one copy of a paper (e.g. for more than one family in an apartment building) has to use some local storage and has to print the desired number of copies of each page, before continuing to print the next page. (This will place a limit on the number of families sharing a printer).

Finally, it should be made clear that the notion of so-called "multi-time" paper as speculated in [10] would add still a further dimension to facsimile newspaper delivery.

4. THE IMPACT OF 1WW (ONE-WAY WIDE-BAND) VIDEOTEX, THE USE OF CABLE TV, AND DIRECT-BROADCAST SATELLITES

1WW videotex can be transmitted either via a dedicated broadcast channel, or via a separate CATV channel. To the authors' knowledge the only major experiments conducted in this direction all use CATV. Since this alternative is particularly attractive in a country with high CATV penetration it is not surprising that Canada (where over 50% of households are already equipped with CATV) leads in this area.

Cable TV is most suitable for this type of application since on average it can carry up to about 40 different channels of TV and hifi-audio programs. One major problem is to actually "fill-out" the capacity of CATV networks with high-quality TV or audio programs or, as in our case, with other useful applications. For example, at the time of writing, the local cable TV company of Vienna, Telekabel, provided only six different programs (two Austrian, three West German, and one Swiss) and 16 audio programs (Austrian and West German). This service -- apart from those areas where the quality of local TV reception is poor -- only provides a real new service in bringing to Vienna four foreign TV channels and a few Bavarian radio channels. If, however, one takes into consideration that both Switzerland and West Germany are planning to launch their direct-broadcast satellite with Swiss and German TV programs around the second half of the 1980s, then the local cable TV company will not really bring in new services to the Vienna area any more -- apart from the "resource sharing" effect of the central dish, antenna to the direct-broadcast satellites, and the necessary frequency converter. In the long term, however, when the broadcast power and used frequency band of direct-broadcast satellites increase, then the size and cost of the dishes will come down to enable them to be installed on the roofs of houses, if desired. Therefore cable TV companies have to look for additional novel services to attract customers. We believe that 1WW videotex services (preferably using several channels) belong to this later category.

At this point we would like to make some remarks on the use of direct-broadcast satellites for broadcasting 1WW videotex services. At present, many countries are making preparations to launch their own direct-broadcast satellite systems. Some of them, such as India, Columbia, and the Arab countries, do not have their own fully developed terrestrial TV networks. Others, such as Canada and Australia, provided the vast majority of their populations with TV programs but due to the geographical peculiarities of these countries, there are huge, sparsely populated areas where the build-up of terrestrial TV networks cannot be justified financially. For these two categories of countries, direct-broadcast satellite systems as we know them today are not or will not be a luxury, but a necessity. There is, however, a third category -- such as the European countries -- which are smaller geographically, and in addition, possess well developed terrestrial TV networks with practically full geographical and population coverage. Most of them even have networks for distributing two to three nationwide TV programs. In these countries, the direct-broadcast satellite system arrived 25-30 years later than what would have been ideal. Nonetheless, some of them (the UK, France, West Germany, Switzerland, Luxembourg, Monaco, Italy, Austria, Yugoslavia, etc.) are planning to put their direct-broadcast satellite systems into operation soon. There are different driving forces for them to do so: some of the countries are "running out of frequencies." For example, the setting up of a fourth national channel in West Germany would not be possible because of frequency congestion. Other countries, especially the small ones, are homes of commercial TV companies (e.g., RTL in Luxembourg and Tele-Monte-Carlo in Monaco) which plan to broadcast commercial programs and especially advertisements for audiences in neighboring countries. RTL, for instance, would be received in Lyon and Hamburg and would thus cover half of France and three-quarters of Germany. It is therefore feared in those countries that these commercial programs would strongly compete with the national ones.

Other countries, such as Austria and Yugoslavia, see this tool as an excellent medium for conveying national culture beyond their borders. The Austrian direct-broadcast satellite system would be able to provide 55 million people both in Austria and neighboring countries with Austrian program. In Yugoslavia -- a country with six republics, two autonomous regions, and several languages -- there are expectations that such a system would create closer cultural links between the republics and regions, and at the same time improve the regional service. There are still a few countries in Europe where, because of geographical difficulties, the terrestrial networks could not be completed yet. A typical example is Norway, where this new technology could lead to considerable savings both in time and resources. Also, a third Austrian and Swiss program -- if the time comes to build it up -- would be better implemented using this technology. According to [31], for example, for Norway to achieve a 95% coverage of the population it would require 154 VHS transmitters and 1,000 repeaters. In addition (due to the severe climatic conditions) the annual operation cost of the network would be of the order of US $65 million. In the UK, where geographical conditions are far more favorable for terrestrial systems the annual operating costs would be about US $10 million per TV channel. In Italy and in France, it would be around US $15 million per year, respectively. According to [31],

> The annual cost per channel for a satellite based operation network with five channel satellites would be in the order of eight to nine million US dollars. The system wold consist of two satellites in orbit at any given time (one active satellite, one spare) and related ground facilities (a telecommand telemetry station and the TV transmitting station). All the elements of the system would be insured against failures. The annual cost per channel could increase to about 12 million dollars in the case of the most power demanding mission and on the contrary decrease to about 6 million dollars for smaller coverages.
>
> A five channel satellite providing coverage over France or Italy for instance would lead to an annual network cost reduction per channel in the order of 6 million dollars, i.e., about 40% reduction over the classical terrestrial network and allowing at the same time a near 100% coverage. In the case of smaller coverage area as for Britain and Germany, the percentage reduction will be lower. It would, on the contrary, be much more for countries specially difficult to cover by terrestrial systems as, for instance, Norway, where the savings in operation would be about 54 million US dollars per year. Thus, broadcast satellite systems seems to be cheaper from the operational point of view.

As to the minimum initial capital investment cost of a direct-broadcast satellite System, according to [32], the following components have to be taken into consideration:

(a) Space segment (satellite, launching, insurance premiums).

(b) Earth segment (up-link transmitters, down-link receivers (dishes)).

Some typical cost elements for present and future direct-broadcast satellite system are shown in Table 1.

As to the cost of up-link transmitters and down-link receivers, the higher the frequency used, the more costly the up-link transmitters. Up-links in the more preferable 14 GHz band costs are about US $500,000 at present for a transformer and transmitter, i.e., twice as much as for a similar equipment in the 6 GHz band. It is expected that these costs will drop as time passes, and will level off at around US $50,000. Down-link receivers, on the other hand, get smaller and cheaper with increasing frequency and power used by the satellite, prices depending on the system and quantity. Disks range from US $100 to 2,000 for the 12-14 GHz frequency band. As to the cost of the satellite, the higher the frequency band used and the broadcasting power, the more expensive the satellite and its launch. Nonetheless, for direct-broadcast satellite systems, where only one or two satellites and appropriate up-link transmitters servicing a large number of users with down-link receivers are employed, it is more economical to use as high frequencies as possible. This philosophy was also adopted by the ITU and World Administrative Radio Conference (WARC) which allocated in 1977 higher up-link and down-link frequencies in the 12-14 GHz band for direct broadcast purposes.

In any discussion of the role of direct-broadcast satellite systems a key issue is the problem of program content. This is a crucial question, particularly for countries which already operate TV programs on well developed terrestrial networks because an entirely new program for the sake of a direct-broadcast satellite System seems to be wasteful and too expensive. According to [32], 10 hours per day of general TV programs costs US $36.5 million per year to produce (CCIR Data Report, International Radio Consultative Committee).

According to the present allocation of WARC frequencies in Europe, Africa, and Asia, each country is allocated five specific channels (with 27 MHz bandwidth) for direct-broadcast purposes. At first this certainly brings the problem of economic utilization: a country such as Austria, for example, will find it difficult to fill its allocated channels with useful programs. However, the more channels are used, the lower will be the cost per channel for a satellite which can easily accommodate a few separate TV and radio channels. Therefore, in order to utilize fully the capacities of a modern direct-broadcast satellite, either more than one country will have to launch a common satellite for their own purposes; or one country has to utilize its channel differently. *The way we are proposing is to use the "free" direct- broadcast channels for 1WW videotex purposes.* With such a service a reasonable amount of information frames can be rationally provided, as mentioned above, which can be used quite efficiently in a future information-oriented society. The use of direct broadcast satellites for 1WW videotex will, in the long run, enable (by increasing the used transmission power of the satellite and the used frequency in the region of 20-30 GHz) that small mobile dishes and mobile terminals could be used for 1WW videotex purposes.

1.a. Capital costs of present and planned DBS systems

System	Total Cost ($m)	Satellites* ($m each)	Launch** (Date) ($m each)	Insurance Premium (years)	Design Life	Satellite Mass	No. of transponders	Receiver costs
Average DBS System	171	25 (Q=3)	30	2	8	200-800 kg	2/4 channels	$200-500
ANIK B (Canada)	63	34 (Q=1)	29 (1978)		7	400 kg	6 channels	$500
ANIK C (Canada)	165	22.5 (Q=3)	29 (1981)	1.54	8	522 kg	16 channels 32 TV	$3300 (Q=100)
BS-1 (Japan)	115	50 (Q=2)	13 (1978)		2	352 kg	2	$100-200 (Q=100,000)
CTS (US/Canada)	82.7	72.7	10 (1975)			350 kg	2	$15,000(10ft dish) $23,000(15ft dish)
RA-6 (US)	190					1,358 kg	6 (2.6 GHz)	$1-5,000
TDF-1,TV-SAT 38 (France, Germany)	150	35 (Q=2)	30 (1984)		8	135	13	$600-800
NORDSAT (Scandinavia)	370	30 (Q=3)	30 (1985-87)	3.1		?	13	
ARABSAT (ATU)	240	50 (Q=3)	30 (plan)			?	2 DBS	(Q=5,000)
ECS/OTS (ESA) (L-SAT -PLANNING)	250	(Q=3)			7	703 kg	8	$200
INSAT (India)	225	30 (Q=2)	(1981)		7	?	2 DBS (2.5 GHz)	$400
Australia	900		(1985-87)		?			
SATCOL (Columbia)						?	1 DBS	
CONDOR (Andean Nat.)						?	12	
COMSAT DBS	145	35 (Q=3)	12	1.3	8	?	8 channels	$200-400

* see table 1.b

** see table 1.c

1.b Satellite cost breakdown

Component	Cost, $m
Design and test*	20
TTC earth facility	2
Multiplexers	1.2
Orbital positioning equipment**	
Antennae	
Solar panels and related power engineering equipment	0.5-1

* Includes digital T&C systems, some of power and communications electronics;

** Thrusters and stabilizers

1.c Feasible launch vehicles and prices

Vehicle	Cost ($m)	Orbit capacity (kg)
Delta 3914	28	907
Atlas-Centaur	40	1793
N-Rocket(Japan)	75	750
Arianne 1	15	4840
Arianne 3	11-15	4000-11000
Shuttle(US)	11-14	4000-11000

Table 1. Typical cost of direct-broadcast satellite system components [32]

The amount of information which can be offered with 1WW videotex is about 500 times larger than with 1WN videotex, since the full bandwidth of a TV channel (6-8 MHz) can be utilized for teletext. Thus, offering 50,000 pages of information (or more, using a variation of the "magazine" idea) is no problem with 1WW. Since the 2W videotex databases currently in use do not offer more pages than of the same order of magnitude, 1WW videotex will indeed be a rival of 2W videotex as long as 2W videotex is seen mainly as an information service, where the amount of information is large but not super large. However, considering 2W videotex in this way implies a basic misunderstanding of the true possibilities of 2W videotex. It is only because of this widespread misunderstanding which came about because of the ill-conceived *Prestel* experiment in the UK (where 2W videotex has been used primarily as information service since 1979) that it is often assumed that 1WW and 2W videotex are rivals. They are not; 1WW will be vastly superior in performance/cost ratio to 2W videotex (assuming an appropriate CATV infrastructure) in the area of providing large, but not huge, amounts of information which will appeal to a sufficiently large segment of the population or to some extent if no infrastructure (e.g., a telephone network) for 2W videotex exist. Two way videotex is a reasonable alternative to 1WW if an adequate infrastructure for 1WW videotex is not or cannot be made available (for example, if all channels are already occupied with TV programs). If an appropriate 2W videotex infrastructure is available, it should be used for large amounts of data which are accessed only moderately often and, most important of all, for all those myriads of applications where the interaction provided by 2W videotex is essential. The above line of thought will elaborated in depth in Section 7, where the penetration of videotex systems and their components such as the telecommunication infrastructure are discussed.

Regarding the terminals to be used for 1WW videotex preferably an intelligent videotex decoder should be used, the one similar to what has been referred earlier for 1WN videotex sysrems.

5. THE ROLE OF 2W (TWO-WAY) VIDEOTEX

In the initial period of developed 2W videotex development it was often claimed that its main advantage over 1W videotex was the facility to store "unlimited amounts" of information. Although 2W videotex does allow the storage of arbitrary large amounts of data (a fact not only necessary for certain types of information such as nationwide phone directories or large encyclopedias, but also of "philosophical" importance, since it eliminates the need to "select" information, i.e., to exert some kind of censorship), its main importance lies not in its capability as an information service, but its transactional and communication potential. Before going into detail on the latter points it is worthwhile mentioning that even in the information providing sense 2W videotex provides potentials not possible with 1W, or even 1WW videotex.

One such instance is the electronic telephone directory. Even in a small country such as Austria such a directory would have some 2 million entries, requiring an estimated 300,000 videotex frames. This is beyond the capabilities of 1WW videotex.

Another example is the idea of offering a fully fledged encyclopedia via videotex. Ignoring the fact that other technologies such as videodiscs [10] may be preferable in such instances, and assuming that modern videotex systems can handle good quality pictures (as is the case in systems such as *Telidon* [7], AT+T [8], *Picture- Prestel* and MUPID [9], hence obviating the need for locally stored pictures as proposed in [11]), a 24-volume encyclopedia would require some 240,000 videotex frames for text, and another 160,000 frames for pictures. As in the case of an electronic nationwide phone directory or electronic super-directory as proposed in [12], such amounts of information cannot be handled by 1WW videotex. They can be handled by 2W videotex and indeed in a commercially viable way, provided a sufficiently large segment of the population participates. Consider, for example, the situation in West Germany: by 1990, some 5 million 2W videotex customers are predicted. Assuming that 2% of all videotex users are willing to subscribe to an electronic encyclopedia for a fee of US $50 per year (this would compare favorably with the US $1000 buying price for each of the two major German encyclopedias *Meyer* and *Brockhaus*), this would amount to a total revenue of US $5 million per year. Assuming US $2.50 storage charge per page per year (corresponding to the current charges in Austria), $1 million would be required for storage. Based on current experiments, a staff of about 40 would be sufficient to keep the encyclopedia up to date. At a cost of $ 30,000 per man year, $2.6 million per year would remain for the acquisition of material, overheads, and earnings.

Despite the fact that we believe that 2W videotex might be a viable alternative for super-large sets of information (provided the number of users is sufficiently large) we would like to emphasize that this is not most important aspect. (As a matter of fact, due to other more attractive alternatives videotex may never be used this way at all [10].) The importance of 2W videotex lies its transactional and communication capability. It would be repetitive to list once more the abundance of potential applications of 2W videotex described in many recent studies, e.g., [6], [15]; rather, we prefer to make a number of general remarks on what we consider most important.

First of all, we would like to clarify some 2W videotex applications whose significance is often overlooked: we want to distinguish between "answer-type" and "interactive-type" systems. Classical transactional applications of videotex are often only of the "answer type." For example, when teleshopping, the user looks up some goods in a catalogue and then fills out an order form which is sent (electronically) to the information provider. No further interaction takes place between user and information provider, and hence no on-line connection between the two is necessary (this is the reason why for teleshopping *Prestel*-type answer pages are quite satisfactory; access to the information provider's computer is more a luxury than a necessity). Note that even telebanking, the often mentioned standard example of the need for on-line connection between user and information provider, is really of the "answer type": the user retrieves the current status of his account (which could well be done even in 1W mode, by assigning to each account one frame in the videotex computer which is only accessible to authorized users) or carries out fund transfers by filling out an appropriate form. In both cases, contrary to often heard views, no on-line connection between user and information provider is necessary. Thus, the much emphasized on-line dialog between the user and the bank's computer is not essential for such basic applications. The only component which is essential is an efficient message service.

We do not want to claim that videotex networking with interactive access to third-party computers is not important. It definitely is, for certain kinds of truly interactive applications to which we will turn below. What we do want to claim is that for many applications for which direct access to the information provider's computer is often considered necessary considerably less is sufficient: an efficient and safe message service [12].

Indeed, we would like to claim that the value of message services in videotex is grossly underestimated by most people. Such services can be used for transactions (as explained above); for electronic mail; for communication with the deaf; for teleplaying [13]; and for a number of other applications, which form the basis of an important and still virtually unexploited notion of resource sharing via videotex. We would like to elaborate briefly on the idea of resource sharing by means of an example: suppose a user of videotex wants a number of frames of videotex in printed form, or as high-quality slides, or the like. Despite the fact that he may not have adequate equipment himself, he can request the desired output via the message system from a company offering that kind of service.

We would like to turn our attention now to truly "interactive-type" applications of 2W videotex. Despite the fact that such applications are virtually non-existent in 2W videotex systems at present, we believe that they will be developed rapidly and gain increasing importance.

In a truly "interactive-type" application, on-line access to a third-party computer is essential. This is the case where such a computer is used to run a sophisticated program, a game program, or to perform a computation [13]. It is also important in booking situations when rapid confirmation is required. It will play a prominent role in all kinds of teaching applications of videotex, when the instantaneous evaluation of the student's input is essential, and in applications where a third-party computer is used to verify the user's input (e.g. by checking his spelling). A host of other applications is clear to anyone who just cares to think of all the ways in which we use computer terminals interactively through computer networks today. After all, 2W videotex terminals are exactly that: inexpensive, simple computer terminals which will eventually permit access to large computer networks. It is this fact which makes 2W videotex significant beyond what 1WN videotex can ever achieve. With 2W videotex the notion of omni-present access to computer networks is slowly turning from fiction into reality.

We conclude this section by mentioning that 2W videotex will gain much by the introduction of intelligent terminals: not only will these allow more convenient searching procedures (e.g., permitting access by alphabetic keyboards and by "relational queries" in terms of a request form [17]) and the local storage of information, the notion of downloading and executing software [13], so called "telesoftware," will also increase the flexibility of 2W videotex tremendously.

6. THE COMBINATION OF 1W AND 2W VIDEOTEX

In the preceding sections we have argued that each of 1WN, 1WW and 2W videotex are best suited for some applications, but not for all; hence the future coexistence of all three varieties seems a definite possibility. Assuming the widespread penetration of intelligent videotex terminals such coexistence may well turn into a fruitful cooperation, a notion first mentioned in [16]. The processing power and local storage of an intelligent terminal may greatly increase the attractiveness of 1W videotex (see Sections 3 and 4), while some applications may be "split" between 1W and 2W videotex. For example, consider the currency exchange services offered in West Germany via third-party computers: the user accesses a bank offering such service via the gateway of videotex; he enters two currencies A and B and an amount m; the bank's computer now computes the equivalent of m units of currency A in currency B; and sends the result n back to the user.

In a way, such applications are, from a long-term point of view, abuses of the gateway notion rather than reasonable applications thereof. Such trivial computations should be carried out in the user's intelligent terminal rather than overburdening (by thousands of simple requests) a third-party computer. A typical scenario of the future for such an application could be: the user down-loads a (short) program for such currency exchange calculations from 2W videotex; this program fetches one frame of current exchange rates from 1W videotex (where such information is offered anyway) and then performs the desired calculations. Rather than going through 2W videotex gateways and performing some calculation in a third party computer, one page each is retrieved from 2W and 1W videotex, much reducing the load on the 2W videotex system and the third party computer.

From a technical point of view the combination of 1WW and 2W videotex could and should be carried much further except that, in some countries, developments have perhaps already gone too far to make such solutions likely.

The second-generation videotex network which will go into operation in West Germany towards the end of 1983 is based on the assumption that 10% of the information is requested 90% of the time. Hence it seems feasible to use many comparatively small regional videotex centers (for only the 10% of frequently requested information) and a single large center which will send additional frames to the regional centers as requested. Observe that the function of the regional centers could be further reduced (thus decreasing the cost of each of the large number of such centers) if that same 10% of information is distributed via 1WW videotex. The user would not even be aware of this fact: his intelligent terminal would first check for the required information in the 1WW videotex system only when failing retrieve it from 2W videotex. Considering that 1WW videotex usually depends on the ability of a free TV channel on terrestrial networks or direct-broadcast satellite systems, or on the state of the CATV network, the above proposal will only be meaningful in countries where this is available or the CATV penetration is high prior to the introduction of nationwide 2W videotex. This latter point is perhaps not true in some West European countries, but may apply especially to North America, the socialist countries, and the developing world.

The combination of 1W and 2W videotex systems in a given country (as will be shown in the following section) is not only a technical possibility but also a necessity. Thus a country with an underdeveloped telephone infrastructure which is one of the present carriers of 2W videotex has to put its videotex services on 1WW broadcast videotex to the maximum extent possible since it is quicker, easier, and cheaper to develop a necessary infrastructure based on a broadcast medium, as will be explained below.

In Figure 1 we have compiled the presently known main videotex application classes and show which application should be mostly supported by 1WN, 1WW, and 2W videotex systems. In our example, we have made the assumption that all these services are equally available to all users.

7. SOME ASPECTS OF THE MARKET PENETRATION OF 1W AND 2W VIDEOTEX

The few studies dealing with penetration of videotex systems so far have mainly focused on the penetration of teletext (1WN videotex) and videotex terminals (2W videotex) into the domestic and business market of a given country or region. For example, within the framework of a study done for the Eurodata Foundation by the British consulting firm Logica in 1979 [20], it was predicted that the number of home videotex terminals would grow from virtually zero in 1979 to 2.7 million in 1987 in Western Europe alone.

Since the prediction of videotex penetration in different markets is most complex -- and as we will show later, perhaps too complex -- and requires a broad systems approach, we would like to introduce some new philosophical aspects not looked at so far, thus adding new insight into this complicated problem. First of all, videotex has many different aspects to be looked at from the market penetration point of view:

(a) Technological Aspects

Within the technological aspects the following videotex components have to be considered:

- penetration of telecommunication media used for carrying videotex services;
- penetration of videotex terminals including personal computers and intelligent videotex terminals for "receiving" and "processing" of videotex services;

Videotex Applications	Videotex 1WN (normal teletext)	1WW (full channel teletext)	2W (viewdata)
Information retrieval			
–very high simultaneous request by users	X	X	
–high simultaneous request		X	
–medium simultaneous request		X	X
–low simultaneous request			X
–information related to TV broadcast (e.g., upcoming programs)	X		
Games/entertainment			
–games without interactivity		X	
–games with interactivity			X
–downloading of game programs			X
–promotion of TV broadcast (e.g., substitling)	X		
Transactions/teleshopping			
–financial information		X	X
–advertisements		X	
–classified adds			X
–sale catalogues			X
–online ordering			X
–banking transaction			X
Electronic messaging			
–important instant broadcast messages	X	X	
–general broadcast messages of broad interests		X	
–group messages			X
–individual messages			X
–voting			X
Data processing			
–downloading of computer programs		X	X
–access to computers with time sharing service for computation			X
–storage of user data			X
Telemonitoring/home management			
–emergency messages	X	X	
–fire, burgler, medical alarm			X
Education			
–most frequent educational courses		X	
–specialized educational courses			X
–test, examination			X

Figure 1 Suitable videotex applications fow 1W and 2W videotex systems

- penetration of host, switching and gateway computers for "providing" and "channeling" various videotex services;
- penetration of the different videotex service applications offered.

(b) Historical and Economic Aspects

Historical aspects concerning the state of telecommunications, broadcasting and computer infrastructures play a very important role not looked at in depth so far. For example, a developing country with virtually no telephone infrastructure but modest TV broadcast facilities may to build its videotex services primarily in a 1WW videotex fashion within a reasonable time horizon. Economic aspects such as consumer spending patterns play another important role in determining the pace of market penetration both into offices and into homes, not to mention other likely categories of videotex applications.

One of the lessons which can be learned is that within a reasonable time horizon, only the richest countries can expect 2W videotex enter the domestic and business markets; medium-developed countries may expect 1W videotex systems could enter both home and business markets, whereas 2W videotex systems the business market exclusively; and for less developed countries only 1W videotex could have an impact on the business market within a reasonable time horizon, such as the next decade.

(c) Human and Social Aspects

The human and social aspects of videotex penetration are also important. Videotex as known is conceived to be the mass utility tool of the information-oriented society of the future. This, at least in the most developed countries, is expected to happen before long. One of the basic aims is to provide every household and business unit -- not yet computerized -- with a videotex terminal linked to a videotex network to enable the mass application of computers and computing at low cost. Through this technology everybody -- housewife, student, farmer, cook, or city dweller -- is expected to be able to use his or her own terminal and make most use of it. There are major problems in user acceptance, education, and training even for the traditional computer and telecommunications systems which are primarily used in the business world. However, the magnitude of training and educational problems in widespread home computing systems is at present unknown. If we did assume that videotex technology had full market penetration from the technical point of view tomorrow, how many people would be able to use it within a reasonably short time? Also, what would the absorption capacity of the people of a given country be, assuming appropriate training facilities both in quantity and quality existed? Few precise answers to these questions can be given at present, but it probably would take decades even for the most developed societies to take full advantage of what a perfectly developed videotex system could offer. Thus, what should be the desired speed of market penetration from the human and social point of view? We are afraid that this most important question will not be answered in this paper, but we are aware of the fact that it has to be answered in a future study: this question seems to be one of the corner points of a future information society.

(d) Legal and Regulatory Aspects

Legal and regulatory issues may -- and in some countries will -- significantly influence the market penetration of videotex. In some countries at present 1W videotex services can be operated only by certain organizations such as the national radio and TV broadcasting authority, whereas the content of the service is provided by another organization -- such as a national news agency, 2W videotex is operated on an exclusive basis by a third organization, in most cases by the national telecommunications authorities, carrying information provided by many independent users (information providers). In most cases the two different videotex system operators regard each other as competitors or, at best, as operators of two completely different services, and do not fight each other. There is at present no country known to us which would have a favorable legislative environment to support mixed 1W and 2W videotex services. In addition, close coordination of 1W and 2W videotex standards would be needed. A prohibiting factor at present is that most effort is done on the standardization in the field of 2W videotex systems. However, in 1WN-1WW videotex much standardization development work has to be done first, before standardization efforts of 1W and 2W videotex systems can be harmonized as well. Although the above-mentioned topics on human, social, and legal aspects are of great importance, they will not be dealt with in this paper. Therefore, we will only concentrate on technological, historical, and economic aspects in what follows.

Videotex systems as mentioned before are built from the technological point of view on different components such as

- videotex telecommunication infrastructure to carry information;
- videotex hardware and software components; and
- applications (software).

Now we will examine the first two components from the historical and economic points of view. The possible market penetration of different videotex applications (such as information retrieval, games, transactions, messaging, data processing, home management, etc.) will not be dealt with separately in this study, since this very complicated issue represents a broad field of study certainly beyond the scope of this paper.

Nonetheless, references to applications will be made throughout, because we believe that one cannot separate videotex telecommunications infrastructure, hardware, and software from applications.

7.1 Telecommunications Infrastructure for 1W and 2W Videotex

Videotex systems (1W and 2W) as we presently know them are based on different telecommunication infrastructures. 1WN videotex is piggybacked on the broadcast facilities of the TV, but one could imagine that it could also be placed on a dedicated radio channel. At present, 1WW videotex systems are only in their early infancy, only one or two North American cable TV experiments along this line are known to us. Nevertheless, market penetration of cable systems is an interesting phenomenon in this connection. 2W videotex systems as we presently know them are based on the telephone and packet-switching computer networks, and whereas not too many historical statistics exist about market penetration of packet-switching computer networks, extensive and fascinating data are available on the telephone network and its usage. From this, we believe that useful results can be drawn to predict the market penetration of 2W videotex networks, especially from the telecommunications point of view.

Now let us go into the details of some characteristic statistics and curves. In Figure 2 penetration curves of different media such as radio, telephone, black and white TV, color TV and cable TV into US households are shown. The US figures are significant also from the point of view that they represent a country in the forefront of technical development, and in many respects countries with a "time lag" between development and market penetration can make a sample for the potential way of their own domestic development. Figure 2 shows the following interesting trends. Although the USA at present has one of the most developed telephone infrastructures, full market penetration of US households with telephones (we have regarded 80% as full penetration) has taken about 72 years, a surprisingly long period. It can be seen that the development of the telephone infrastructure is linearly proportional to the "richness" of the country. Figure 3 reflects the well known fact that the number of telephones per 1000 population is closely related to the GNP per capita of any country. The GNP figures in the diagrams are expressed in constant 1958 US dollars in order to exclude the effects of inflation on the curve. As it can be seen, all data follow a single diagonal line; the developing countries with low monetary resources and thus limited telephone infrastructure are at the lower end of the curve. Austria and Japan lie somewhere in the middle, whereas the richest countries such as the USA, Canada, Sweden, and Switzerland are at the upper end of the curve. Surprisingly, some rich Arab countries are still not within this group, due to the fact that in order to have a widespread, well developed telephone network of US standard it is not enough to be rich, but one has to be rich for a long time, without any disturbance, such as a war*.

* Along the same lines, Figure 4 which shows the development curve of the telephone network for some selected countries, provides more evidence of this.

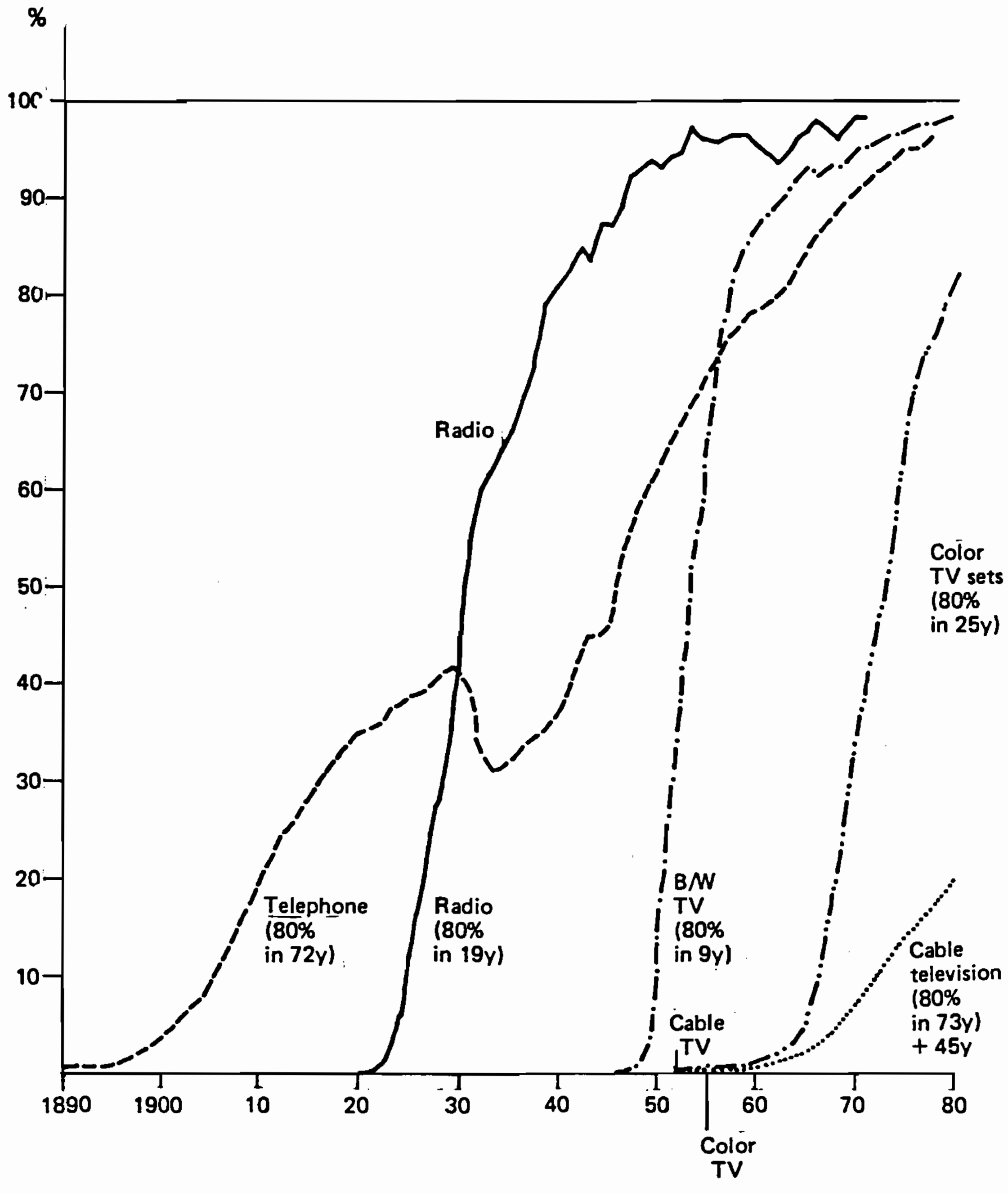

Figure 2 Penetration of households with telephone, radio, TV sets in the USA (%) [23, 24]

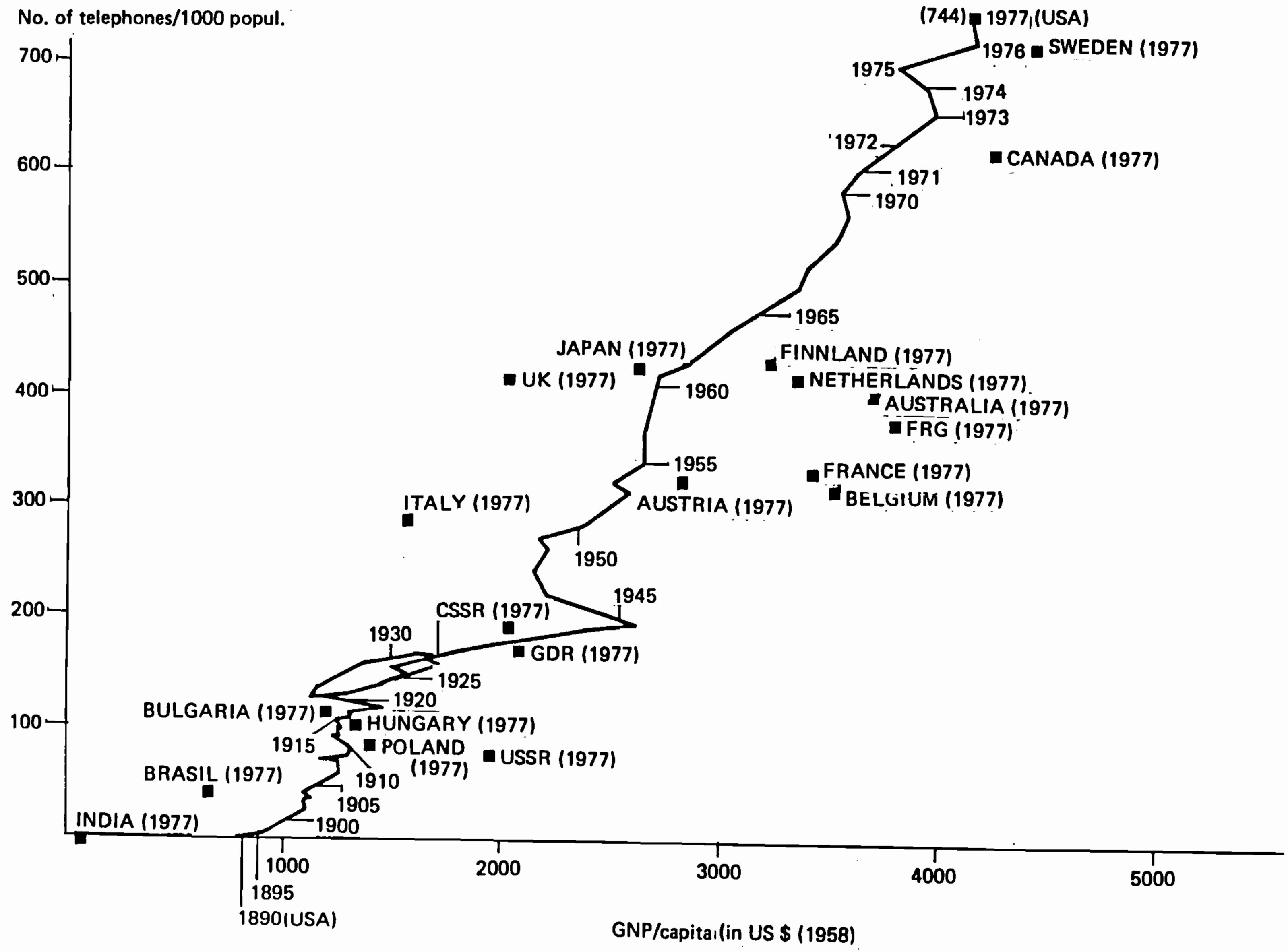

Figure 3 Number of telephone per 1,000 population in 1977 for selected countries and for the USA between 1890 and 1977 [22, 23, 26]

In Figure 3 it is most striking to follow the development pattern of the US. It is remarkable that between the two world wars at the time of the economic crisis, recession, and growing population, there was a long period with practically no strong upward trends. Only from the time that preparations for World War II began, can one see some improvement. During the war, obviously no major investment in the telephone network was made, although the GNP per capita increased because of the increased industrial output needed for the war machinery. Constant development can be observed, however -- again along the diagonal line -- after World War II. Now Figure 4, one may state that the development curves of individual countries are more or less parallel to each other with the exception of the US, which developed rapidly between 1890 and 1910. In general, richer countries are ahead of poorer countries and the development of the telephone network requires a long time period. It is also remarkable how one can follow the history of each country along the line of its telephone development: the recession in the early 1930s in the USA and Canada, the Civil war in Spain between 1936 and 1939, the impact of World War II on Poland, etc.

One lesson for the developing countries with less developed telecommunications infrastructures is that if they want to copy the present type of telephone network of the developed countries it will take very long time to build, and huge resources will be required. From the "philosophical" point of view it is questionable to start to build up a telecommunication infrastructure now, based on a wired analog telephone network.

One can observe from Figure 2 that the well known "S"-shape of telephone network development started to grow in the first decade of this century, and then in the 1930s because of the economic crisis -- families had to cancel their telephone subscriptions. Then, with the wartime economic boom, the growth of telephone penetration increased. Apparently, the economic difficulties of the 1930s led to a delay of 8-10 years in the penetration of telephone in US households.

A similar type of development pattern seems to be true for cable TV networks which only emerged in the USA in the early 1950s. If the present trend continues, then an 80% penetration of cable TV in the US can only be expected in about 70-75 years, so that the development pattern of this other terrestrial network is quite similar to that of the telephone. The exceptional geographical situation of a country such as Canada, where, as mentioned previously, the penetration of cable TV has reached about 50% of households, seems to be a contradiction. But this fact can be ascribed to some specific Canadian aspects, such as similar culture, the same predominating language, the fact that the majority of the Canadian population lives in cities close to the US border, but not close enough to receive US TV broadcasts directly, etc. Consequently, the Canadian cable TV development curve is steeper than that of the US. With regard to cable TV network development, some other factors have to be taken into consideration. An important factor which will probably influence the market penetration of cable TV is that the role of cable TV is changing. During the first 30 years of its existence its major role was to bring TV broadcasts of high quality to homes, but now it is becoming the backbone of broadband communication allowing, for example, 1WW videotex (with reverse channel possibly even 2W) and other innovative

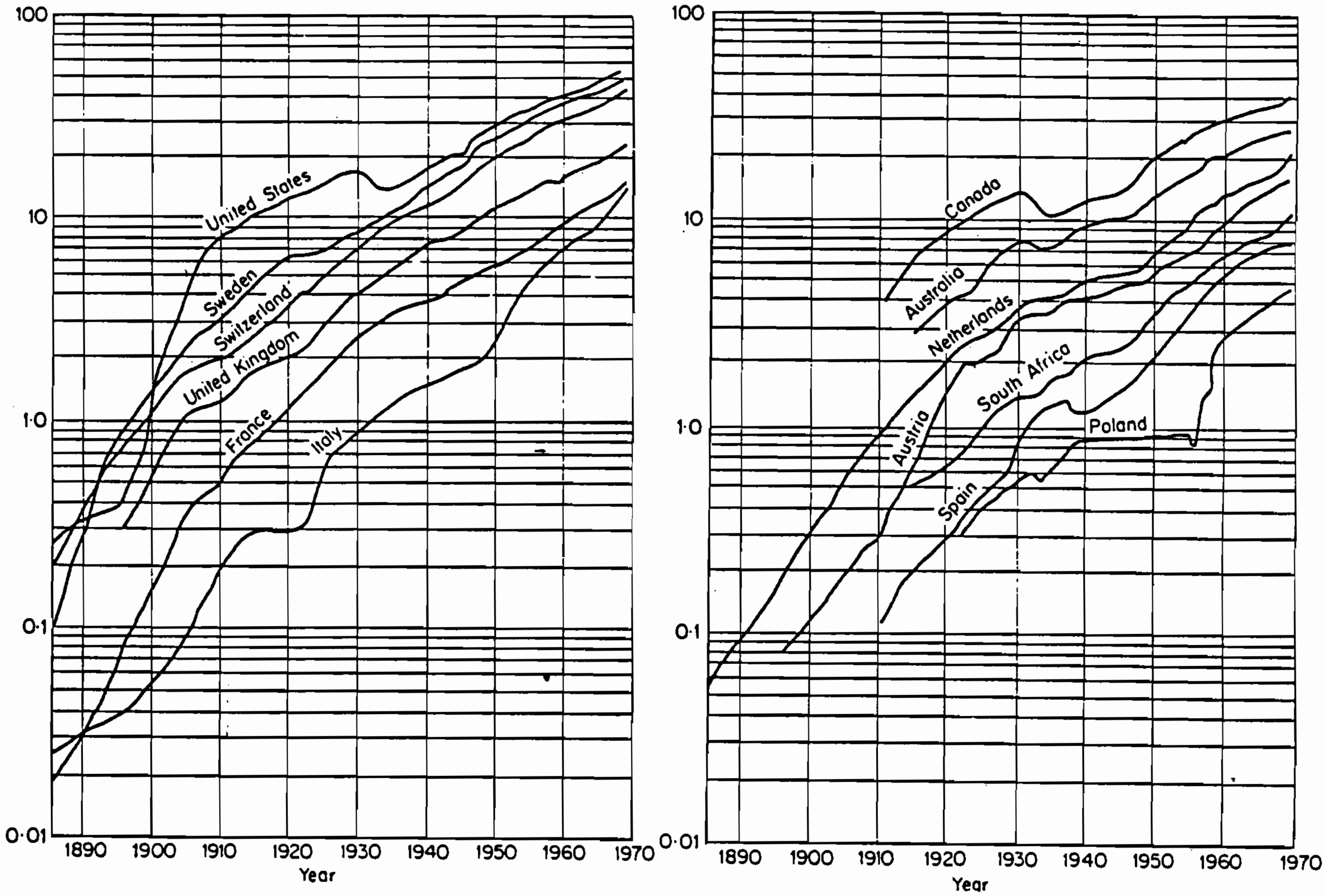

Figure 4 a and b   Telephones (stations) per 100 population in various countries (Groups A and B) [25].

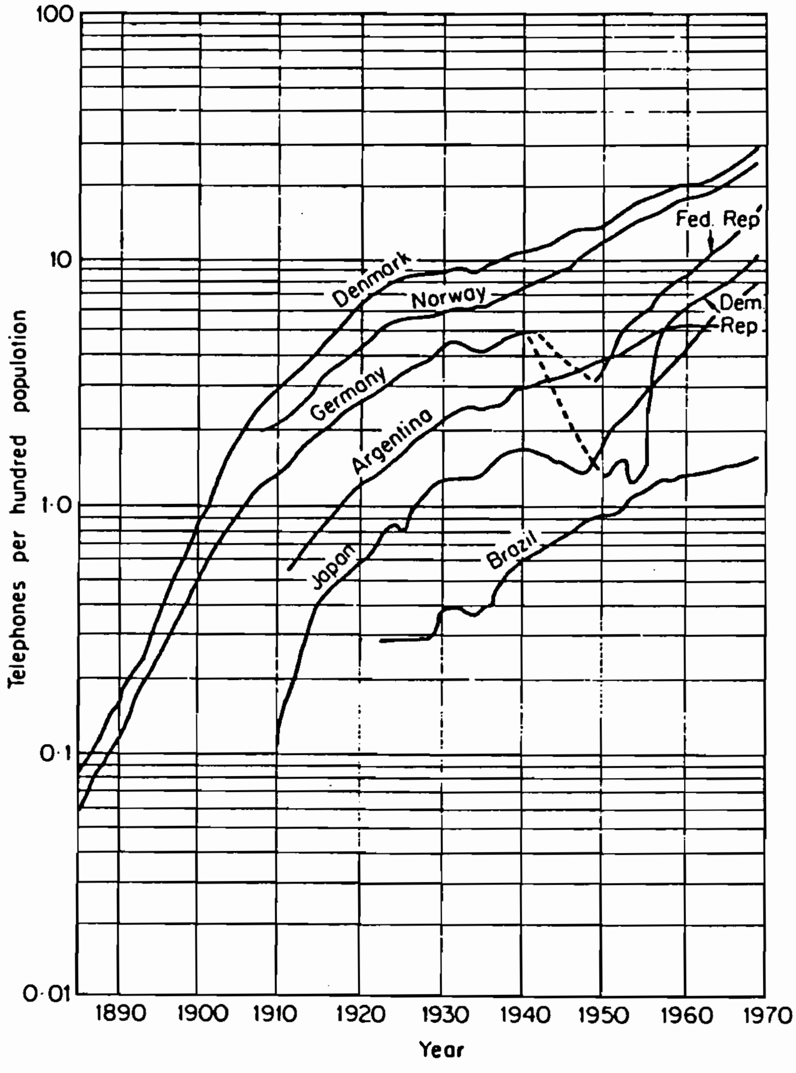

Figure 4c Telephones (stations) per 100 population in various countries (Group C) [25].

types of applications which no one thought of at the time these cable TV services were first introduced. In a sense we see same phenomenon happening to 1W and 2W videotex. At present we are still in the learning phase, when these media are changing and developing, and providing new services, and thus in turn having a major impact on the market penetration process. This phenomenon is relatively unique. We do not see it in the development of telephone, radio, and TV broadcast services, whose primary service functions have have not changed over time.

One of the most important observations one can make on the basis of Figure 2 is the fast market penetration of radio, black and white, and color TV services. The fastest was achieved by black and white TV: in about nine years a market penetration of around 80% was achieved in the US, one of the shortest mankind has ever experienced. Strangely enough, a similar "figure" was achieved in the last decade by pocket calculators too. However, such rapid market penetration patterns are rather unusual even in the information and microelectronics industry. For videotex, lower figures can certainly be expected, as we will show later. There is one very important aspect of the similarity of radio and TV penetrations: their telecommunications infrastructure is based on "ether" broadcast technology, and thus no time and resource consuming cabling was needed when it had to be put into operation. Another reason for the success of these two media are, we believe, that when they entered the market they offered a completely new type of service with practically no competitors, so that the substitution effect was negligible. TV had some competition from movies in the entertainment category, which was easily won by the television, as all statistics prove.

With the telephone, this was not quite the case. This medium belongs to the category of individual communications such as telegraph and mail services, which did indeed compete with each other to a certain extent.

At the beginning, radio certainly had some strong competition from newspapers in the field of news delivery, it proved to be more useful when news had to be provided instantaneously, whereas newspapers were better at bringing full details on news, analytical articles, etc. There was obviously no competition in the field of "audio information" such as music. A type of competition does exist to a certain extent between TV and radio, for example, in bringing news on events where no pictoral information is available or where it is of secondary nature. Nonetheless, looking at historical statistics, in no country did the introduction of TV have a serious influence on the popularity of the radio. In the US, in the early 1950s, a brief drop in radio sales was observed; but this was the period when in homes new investments in consumer electronics were placed in buying TV equipment. A short decline (we would call it rather a "disturbance") of radio penetration was reported after 1960, but this was during a period when radio as such could be regarded as fully penetrated into the domestic market. In connection with the market penetration of radio in the US it has to be mentioned that, according to Figure 2, its penetration was not significantly influenced by the economic crisis of the 1930s or and World War II.

This phenomenon is, however, not quite true for less "rich" countries, as we will show on the basis of some Hungarian statistics. In Hungary (Figure 5), radio started to penetrate the domestic market in 1925, and growth was exponential up to 1930. Between 1930 and 1940, due to the severe economic situation of the country, only low growth figures were achieved. No figures are available for the period of World War II. After the war, the radio service in Hungary had to start right from the beginning, most of the radio receivers had been destroyed, and the number of radio licenses exceeded the pre-war level only after 1948. From then on, however, the penetration of the radio simply followed the "normal" "S" type of growth curve, similar to that shown for the USA in Figure 2. Thus, without an economic crisis or war in Hungary an 80% penetration could have been achieved in about 18 years. However, due to the above mentioned events, a delay of approximately 17 years (!) was observed. Thus, not only technology, market forces, and legislative factors count!

With regard to TV penetration in Hungary, a development curve similar to that of the US can be observed. There was a time delay of only nine years, but the maximum penetration level in Hungary was also achieved roughly within 20 years, similar to the US. No detailed statistics have yet been published on the penetration of color TV in Hungary. Color TV broadcasting on an experimental basis started around 1968, while in the US this stage was reached in the late 1950s. The US color TV market penetration curve closely follows that for radio and black and white TV services, as can be seen from Figure 2. In 1980, the level of penetration in the US had reached 80%, making it one of the few countries where a full penetration has been achieved. If the Hungarian color TV curve follows the same pattern to 1980 this would be around 15%, and this, we believe, is not very far away from the truth. This rather long explanation was needed in order to introduce Figure 6, which shows the number of TV sets per 1000 population in relation to the "richness" of the country -- the GNP per capita, again expressed in constant 1958 US dollars. The curve has two different parts: part 1, in the region of lower GNP per capita (this is the region of developing countries), shows a stronger dependence of TV sets on the GNP per capita figure. This first phase changes rather rapidly. In part 2 of the curve (representing developed countries) practically all households can afford to buy TV sets, and have already done so. The question in the higher GNP per capita region is whether families should buy their second and third TV sets or not, and what to do with the first one. In the US and Canada, most households have second and third TV sets. This situation is obviously connected with the average housing style (large family houses) of these countries, and the fact that used TV sets have practically no resale value.

With regard to 1W and 2W videotex the main lesson to be learned from the above considerations is as follows.

The communications infrastructure needed for 1WN and 1WW videotex can be built relatively cheaply and quickly since narrow- and broad-band teletext only require a radio or TV channel, a radio or TV broadcast station, and appropriate TV sets with a teletext decoder, or a personal computer equipped with teletext decoder. Since the price of a single teletext decoder is low in comparison with that of a TV set it is expected that all households can buy the necessary equipment in one

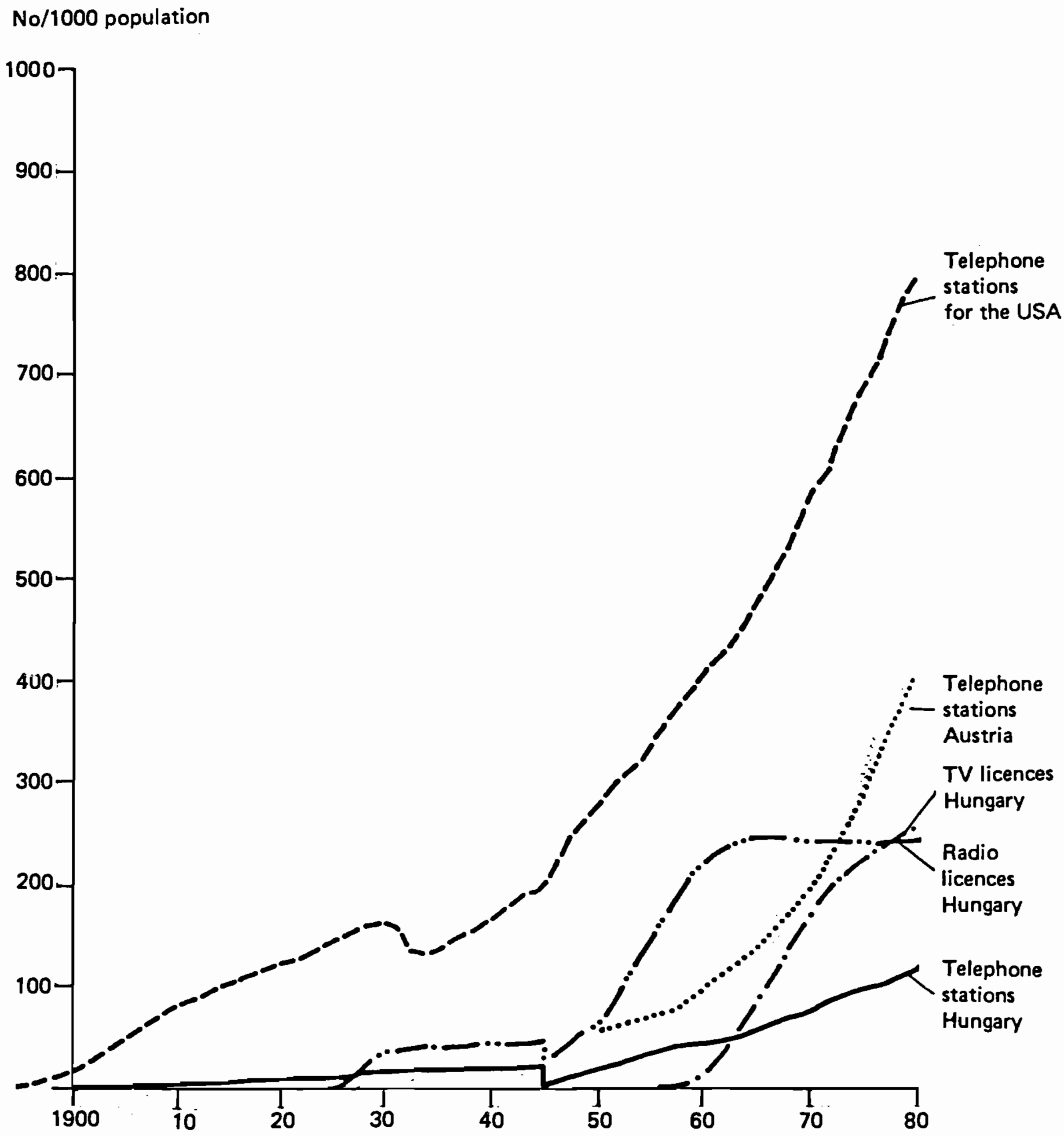

Figure 5 Number of TV/radio licenses and telephone stations per 1,000 population in Hungary [30, 33]

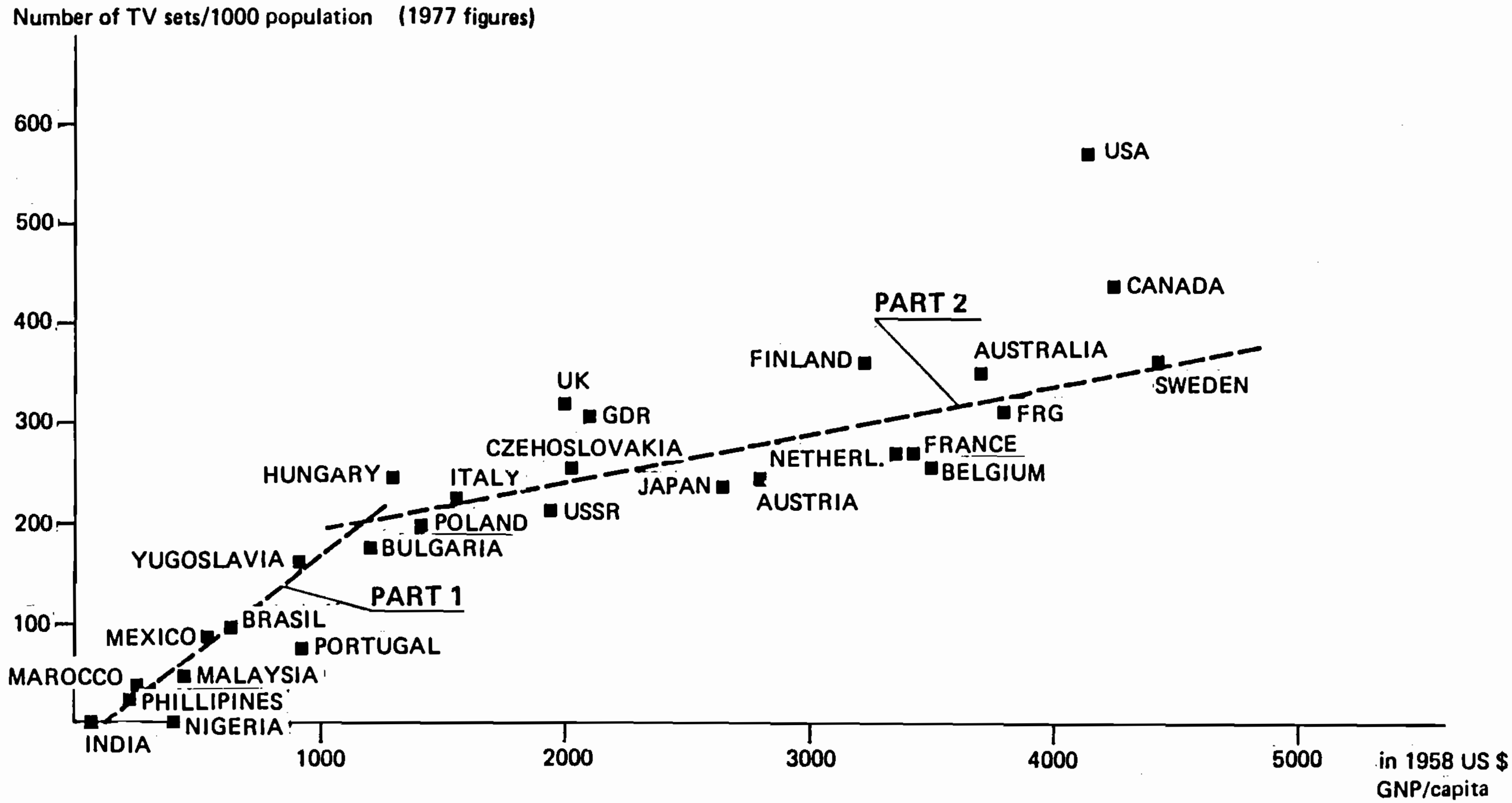

Figure 6 Number of TV sets per 1000 population in selected countries according to 1977 figures

form or another, and it is expected that households in developing countries will also be able more and more to have their own teletext-equipped TV sets. Thus from this point of view in the developing world 1WN and 1WW videotex should become more viable and, we believe, be of greater importance in the domestic and small business market than 2W videotex, as we will show below.

With regard to the telephone network, which at present represents the telecommunications basis for 2W videotex systems, some further observations can be made.

As mentioned above, mail, telegram, telex, telephone, and more recently, teletex are individual types of communications forms. They differ by nature significantly but in some application areas they overlap each other; often, telegrams can be replaced by telephone calls, mail by telex, letters by telephone calls. We have also shown in [12] that there will be a great potential for 2W videotex systems to replace mail and telephone. This interdependence and substitution pattern can also be observed on these historical statistics which we have taken here as examples. Figure 7 shows the situation for the United Kingdom between 1840 and 1980. First of all, the total amount of individual communication by a person within a given year increased considerably. During the last century, when the telephone was not invented yet, individual communication was done, first of all, by mail and, in urgent cases, by telegrams (in our figure; obviously direct person to person communication -- i.e., personal discussion -- could not be taken into consideration). The amount of letters and telegrams per person grew accordingly.

Around the 1880s the first telephone systems were put into operation. One of the impacts of the telephone service was that for handling urgent messages the use of the telegraph service started to decline. The peak of the telegram service in the UK was about 1900, and has declined rapidly, since then. Some temporary peaks can be observed during periods such the two world wars, the reasons for which are obvious, but overall, the number of telephone calls per person increased exponentially. The third category, mail traffic per capita, increased slowly but steadily between 1840 and 1968 except for war periods where, in the UK, it fell back. In 1968 the mail traffic apparently reached its height and now it is very likely that it will go "down hill". What happened? First of all, one part of the mail traffic was taken over by telephone calls, and in addition, computer mediated message traffic began to increase. In the early 1970s, first "long-distance" computer-computer connections went into service, resulting in a great deal of the corporate traffic of major organizations being put on data lines. In addition, financial transactions are increasingly been pursued on dedicated banking computer networks such as Swift. In the long term, it is expected that videotex will have an effect on the mail traffic, and that this will lead to savings of energy, material, manpower, etc., and that it will improve the quality of the somewhat deteriorating mail service. According to the statistics of the PTTs themselves [e.g., in 30] the mail service worsened during the last decades because of its inability to handle so many mail items. Regarding mail traffic, the historical figures both for the US (Figure 8) and Hungary (Figure 9) show the same trend. In the US, the telephone has always played a larger role than letters, so that the number of telephone calls per person

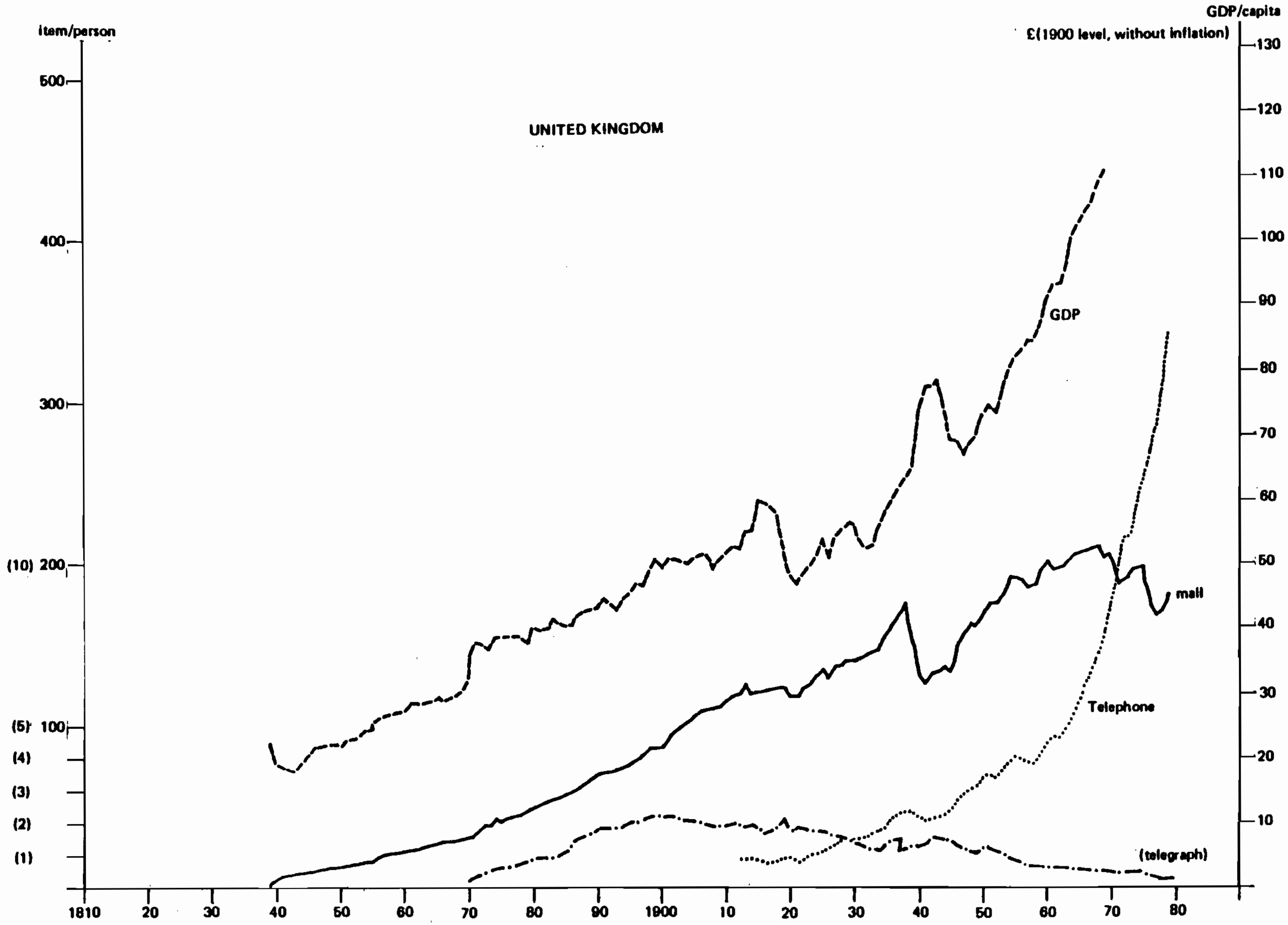

Figure 7 GDP per capita curve and number of mail, telephone calls, telegraph messages per person in the UK, 1840-1980 [27, 28].

has been always higher than that of letters, even in the 1920s. Today the discrepancy between these two is still growing. In the US, one person makes six times as many telephone calls as writing letters, whereas in the UK (in 1979) only twice as much, and in Hungary only about 1.2.

Hungary's historical statistics show -- as mentioned before -- the same trends, but they also show some other interesting features. First, due to the lower level of development of the telecommunications infrastructure of the telephone network in Hungary, mail has maintained its predominance. In times of war, mail traffic increased dramatically (who knows why to that amount?). After each war -- needless to say that both were lost and the country was in state of chaos -- the entire mail, telephone and telegram system collapsed, as is well reflected in Figure 9. In 1977-78, seemingly, the peak of the letter traffic was reached. Now the mail item per capita figure -- similar to the UK -- is falling back.

Secondly, the telegraph still plays an important role. Its traffic clearly increased during wars but even today there is still a continuous growth trend, mainly because the quality of the mail service have worsened and the telephone network is not as developed as it should be, not to mention the quality of service.

Thirdly, the development of the telephone shows an interesting picture as well. It is well known, that Hungary was in the forefront of the telephone development in the last century. The first telephone exchange, for example, was designed by a Hungarian, Tivadar Puskas, and in Budapest, the second telephone exchange in the world was built. Up to World War I the development of the telephone followed a normal -- but slow -- exponential growth curve, but as a result of losing the war, and the financial crisis of the 1930s the service deteriorated, and in 1944-45 it completely collapsed. Later, high growth levels were achieved by 1950. Then, due to government investment policies, this rate went down slightly, and only after another change in government policy it in 1970 did start to increase more rapidly again. Finally, in 1979-80 more telephone calls per person were placed in Hungary than letters written. Nevertheless, Figure 5 allows comparison between the growth curves of the US, Austrian, and Hungarian telephone network. In spite of the considerable developments of the Hungarian network after 1945, its pace in comparison to the US and the Austrian system is still slow. If the present trend continues, and due to the present economic situation, there is little hope for Hungary to have a reasonable telephone network penetration for the next decades. With regard to this fact, it would seem advisable to seek for other telecommunications media such as 1WW videotex, and perhaps 2W videotex, to ease the situation in the future.

The historical statistics for these different countries show that in the mail services dramatic changes can be expected in the next couple of decades. It seems that, from the technical, economic, and labor viewpoints, mail services are approaching their limits, are more and more likely to be taken over by other electronic services. The recognition of this trend is certainly not new, but it is useful to support this claim with some historical statistical data. Therefore, there are great potentials for 1W and 2W videotex systems to take over some portion of the telephone and the mail traffic as indicated in [12], where it has been shown that

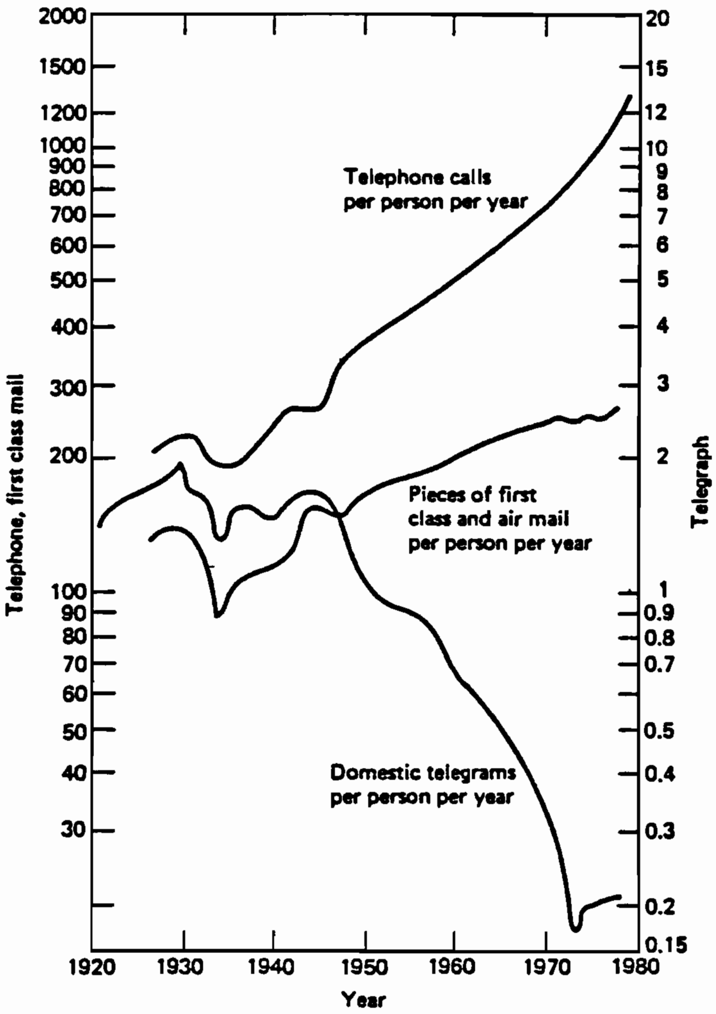

Figure 8 Number of telephone calls, pieces of first class mail and air-mail, and telegrams per persons per year in the US [23, 24]

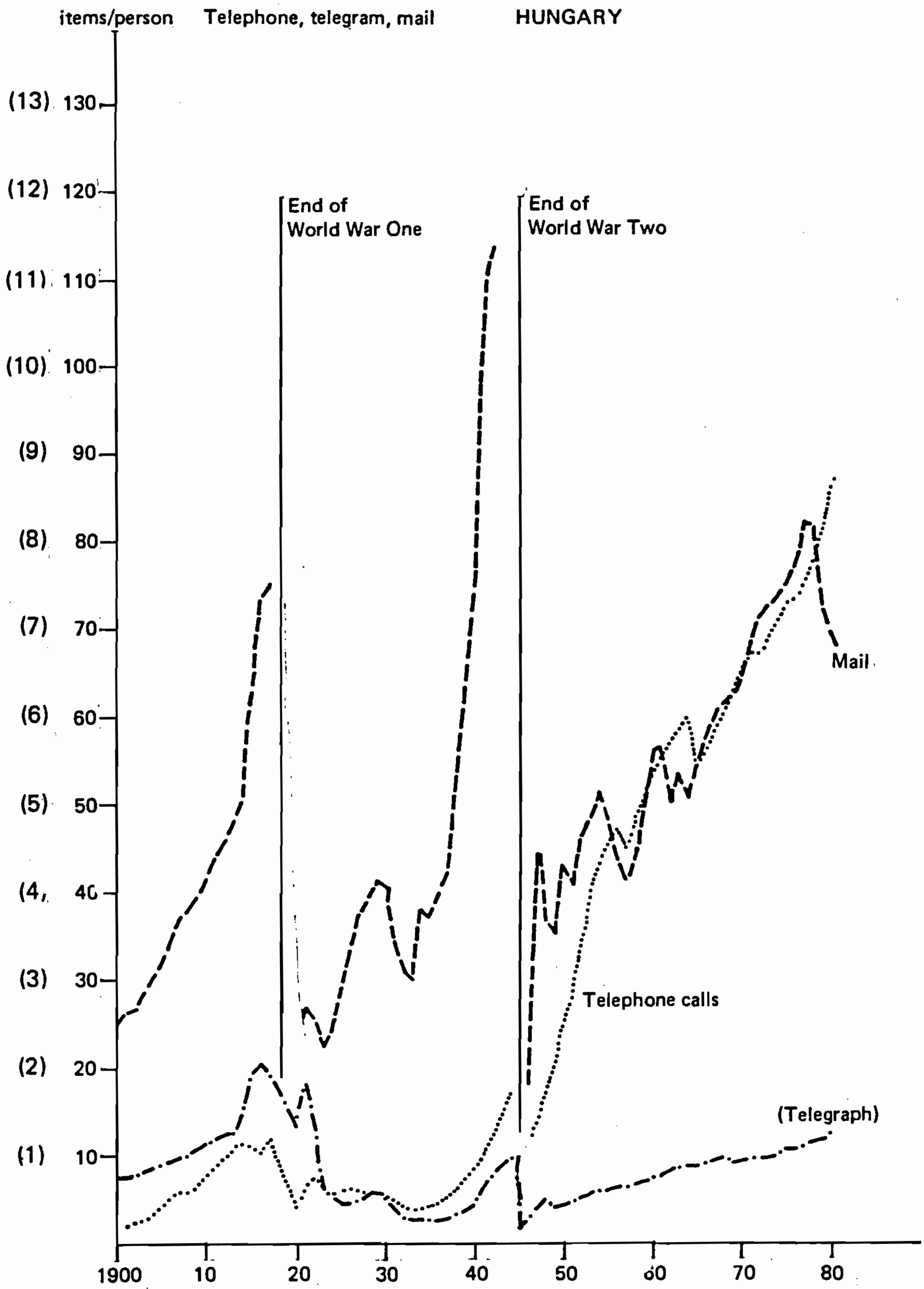

Figure 9 Number of mail, telephone calls, telegraph messages sent per person in Hungary between 1900 and 1980 [27, 28]

about 50% of the telephone traffic could be taken over by 2W videotex. As pointed out in [12], the electronic message sending function of 1WW and 2W videotex could, in addition, take over much of the mail traffic which could be transferred electronically. Table 2 (based on data from West Germany [3]) gives a short overview of the types of mail communication that in principle could be taken over by 1WW and 2W videotex systems.

It can be seen from Table 2 that, theoretically, most of the present mail traffic could be transferred to either 1WW or 2W videotex, or both. If the appropriate infrastructure for 1WW or 2W videotex existed in a country, one could channel "individual" mail traffic to 2W videotex and broadcast (receive only) type of traffic such as "mass" printed matter to 1W videotex. A country with an underdeveloped telephone infrastructure, however, would not be able to put too much or any traffic on a telephone/computer-network-based 2W public videotex system. As pointed out earlier, the build-up of an appropriate terrestrial system would take decades. In such cases it would be possible in principle to put mail traffic on 2W broadcast videotex systems, working on packet radio principle. Such systems do not exist at present and no plans for implementation are known to us. It is also feasible that only incoming mail

Table 2. Type of mail in West Germany in 1973 [3]

Type of mail	Billion items	%	In principle transferable to 1W videotex[1]	In principle transferable to 2W videotex
Letters	5.63	58.6	X	XXX
Printed matter (letters)	0.35	3.7	X	XXX
Other printed matter (journals, books, brochures, etc.)	0,86	9.0		X
Postcards	0.78	8.1	X	XXX
"Mass" printed matter (advertisements)	1.45	15.0	XXX	XX
Miscellaneous (book parcels, samples, parcels, etc.)	0.54	5.6		
Total	9.61	100		

XXX suitable
XX feasible
X in principle feasible, especially for 1WW, but rather "unorthodox"
1 only to receive mail

traffic would be received through 1WW broadcast videotex. One question which certainly arises with message sending through broadcast videotex is data (or, more precisely, message) security, although this problem could be solved relatively easily with the help of so-called public-key cryptosystems. Such systems would work [4] with an individual known encryption for each subscriber, which would not thereby reveal the corresponding individual description key, defined and solely owned by each subscriber who wants to receive the messages. The encryption key, however, would be "announced" publicly and put as information on the broadcast videotex systems. Methods for generating corresponding encryption and decryption systems are known in the literature. The definition handling of such encryption keys at the user's site would obviously require an intelligent videotex decoder with local processing capabilities.

Such systems, however, are a long way off yet. As to channeling voice telephone traffic to videotex, transferable telephone calls would appear as electronic messages as well, which could be handled mainly by 2W videotex systems, but also a limited way with 1W mode. As to the implementation for 2W videotex delivering electronic mail systems; these are already in use in the UK. In late 1981 *Prestel* has introduced such a new software system, and Austria is planning to follow the UK example soon. This 2W videotex service is expected to become operational during March 1982.

Also for 2W videotex delivering electronic mail, Butler, Cox and Partners [19] expect a rapid growth of different electronic mail terminals in Western Europe (Table 3). They expect that the 2W videotex terminals would be the majority of all electronic mail terminals, including telex, in Western Europe by 1983.

7.2 Videotex Hardware and Software System Components

Computer hardware and in particular the availability of videotex terminals is the next factor to be examined with regard to the limits of market penetration of 1W and 2W videotex technology. As mentioned earlier, microelectronics and computer technology is used for different components of videotex technology. For example, host computers for storing and processing all kinds of information which are to be serviced through

Table 3. Electronic mail terminals in uses in Western Europe, 1979-83 [19] (installed based in thousands)

Terminals	1979	1980	1981	1982	1983
Viewdata	5	45	175	355	855
Facsimile	35	47	70	103	151
Telex	378	408	441	476	513
Word processors	75	95	122	154	194

the videotex network; the the present 2W videotex network itself is built upon telecommunications switching computers. These allow the desired data traffic between users and information service centers, or to any other type of videotex service computers such as for electronic mail, teleshopping, telecomputing purposes, etc. In case of the presently known 2W videotex networks -- as mentioned before -- the backbone of the computer network is often the national packet-switching network. Videotex switching centers tend to play the same switching role between videotex users and host computers -- linked either directly or through the national packet-switching network -- as the node computers of any computer network would do. All in all, for the computer communications component of videotex, "heavy" computer technology is needed, especially for large 2W videotex networks. Moreover, as pointed out in Section 3, computer technology has to be applied in an increasingly sophisticated way at the user's end as well. Nowadays, even the simplest videotex decoders are based on microprocessors. As pointed out, there is a growing tendency to provide more and more local intelligence to the videotex terminals which will eventually become a sort of personal computer (intelligent videotex decoder) dedicated to videotex purposes [9]. As to the average early growth rates of selected technological developments, Table 4, compiled by SRI [21], shows some characteristic figures. Computer technology has shown an extremely high growth rate during the first 20 years of its history -- even higher than that of TV which, as pointed out earlier, had one of the quickest market penetrations ever. The high growth rate for computers, however, received a further impetus during the early 1970s by the introduction of microprocessors and large-scale integration of electronic components. Because of this new revolution, although it is already out of the time span of Table 4, the growth rate of the computer technology did not slow down -- which is quite unique in any innovation process. Thus it appears that the bottleneck in the market penetration process of 1W and 2W videotex will not be created by computer technology as such rather than by the telecommunications component. This trend is true in all regions of the world, but naturally, the penetration of the microelectronics component is delayed in time and speed in the less developed regions.

In addition, videotex technology is based on the assumption of the availability of a cheap, mass-produced technology. In order to secure mass production and low costs the complexity of videotex systems is aimed to be less sophisticated than the "traditional" computer networks and systems.

If one looks around at the present videotex scene, countries such as Finland and Hungary -- who are not in the forefront of information technology development -- have been able to develop their own videotex systems in a surprisingly short time and to put them on the market at about the same time as many of the highly developed countries. The cheap and simple technology in fact provides an opportunity for the developing countries too, which up to now have had to rely on more sophisticated computer hardware and software imported from developed countries, at very high prices.

Table 4. Average annual rates of early growth for selected technological developments (Source: Stanford Research Institute [21])

	Years	Growth rate (percent)				
		First year	First 2 years	First 5 years	First 10 years	First 20 years
Telephone	1876-96	300	200	80	50	28
Telegraph	1867-87	10	17	12	13	11
Television	1946-66	75	370	320	190	58
Microwave	1948-68	0	42	43	33	23*
Automobile	1900-20	85	70	60	50	41
Computers	1951-71	700	400	300	20	84*

* Estimates

With regard to the market penetration of videotex terminals, so much has been speculated and forecast that we do not want to launch new scenarios and model runs to predict possible outcomes. One of the major problems we see in predicting videotex development is that the potential of this new medium is simply too complex, and there are too many actors with different interests in the field (such as the PTTs, information, and service providers, legislative bodies, domestic and business users, etc.). In addition, there are too many technology components and options (broadcasting, wired telecommunications, information gathering, processing, transaction, dissemination, etc.), and the scope of potential application classes which will basically determine the failure or success of this new technology is unusually broad; in this respect, no comparison with radio, TV, or telephone can be made. Finally, there are the potential users of videotex who must be prepared to accept these new, more sophisticated services. Will they be able to master it? If so, how fast?

If one compares videotex with other media such as telephone, TV or radio, as we did in a sense in the previous section, one can observe a basic difference. In the case of these three media after the first period of a year or so of service it became quite clear what each medium was good for, and how it could be used. Since its earliest days (and still today) the telephone is basically used for remote voice communication between individuals; radio to broadcast audio programs for a large audience; TV to broadcast moving pictures "into the households of a nation". The fundamental uses of these media have not changed significantly since their launches, but they did strongly influence our lives. To make forecasts for these types of service is much easier. It is quite clear which needs they can and will fulfill, what is the actual demand for these needs, how much it will cost, how quickly the demand can be satisfied, etc., by the industry, and what legislative or industry policy measures have to be taken. With videotex, be it 1W or 2W, the situation is different; the medium is still changing. Our notion of the needs videotex can or should fulfill was different a year ago and could be somewhat different next year. We all see this new medium as a carrier of potential services, but our perception of the potential usage of videotex is still changing.

Under these circumstances it is most difficult to make a firmly based forecast of market penetration, since the assumptions for different scenarios are too diverse. The first set of scenarios which exists today is based on the notion of "first generation videotex systems", i.e., narrow-band teletext (1WN) and *Prestel*-type 2W videotex used primarily for information retrieval and simple transactions. The second set of scenarios could be based on the notion of the "second-generation videotex systems", i.e., narrow band teletext and cabletext (1WN) and 2W videotex with the concept of the "cheap computer network" supporting a full range of different network applications. It should be noted that not too much forecasting work has been done for this generation of videotex systems yet, even though these services will probably be introduced in many countries in the next few years. However, as described in this paper, we can already see the emergence of "third-generation videotex systems" which will basically include a new concept: the planned and conscious increase of local intelligence at the user's end mainly through dedicated personal computers [9] and intelligent videotex decoders, and then in "fourth-generation videotex" systems the convergence and symbiosis of 1W and 2W videotex systems. According to our present knowledge, no penetration forecast has been made on the set of "third- and fourth-generation videotex system" scenarios.

As an example on what has been done for a 2W videotex market penetration forecast for the European Communities, Figure 10 present some published scenario assumption results of Scholz [22].

They obviously take for granted that a well developed telecommunications infrastructure (packet-switching network and telephone network) exist -- which is or will be basically true for the EC, but is not true for most other countries, especially in the developing world. The assumption for "set penetration" is, according to our judgment, not a free choice, but depends on many other assumptions which follow on the list such as "functions" (range of services), costs, and many others (such as friendliness of the system, level of "computer education", etc.) which are left out, but probably should have been taken into consideration. Concerning "usage price" in the minus scenario perhaps higher prices should be assumed which would seem to be more realistic. Some further assumptions which we feel should also be considered were neglected from the list. For example, a most important factor in the penetration process of videotex is existence of clear government information policy regarding videotex. The backing and support of government, or a decision to "let market forces decide," will probably fundamentally influence the market penetration process in any given country. If, for example, a government decided that videotex should play a basic role in the education system of the country (by enabling modern teaching facilities to be brought to remote mountain villages or farms and thus give educational equality for everyone), then it could restructure its educational policy and invest substantial resources in subsidizing videotex terminals and take away resources, let us say, for textbooks. Apart from the goodwill of the government towards subsidizing videotex in principle, the availability of government funds -- especially in economically and politically difficult times -- is crucial. All in all, we feel that the list of assumptions for the

Assumptions	Minus	Reference	Plus
Set price	high (200 EUAs)	medium (125 EUAs)	low (23 EUAs)
Set penetration	low, partial	50%	tending to 100%
Usage price	low	low	low/high
Usage volume	low	medium	high
Eurochip standard	no	yes	yes
Set suppliers	some TV manufacturers, some sets	all TV manufacturers, all sets	all TV manufactures, plus newcomers
Information, service suppliers	defensive publishers	major publishers, service suppliers, few newcomers	mass entry publishers, service suppliers, plus new suppliers
Functions	information retrieval	information retrieval plus some new	information retrieval plus many new
Regulations	not applicable or restraining	neutral	enabling, facilitating

Figure 10. Assumptions for each of the three scenarios according to [22]

three scenarios in [22] is too narrow. With to regard the "minus" scenario it should be added that from the technological point of view it refers to "first-generation 2W videotex" systems and the "plus" scenario to "second-generation videotex" systems. Now let us come to the results of the forecast. Figure 11 shows the forecast for 2W videotex terminals to be installed in the EC countries, and Figure 12, their usage forecast. Taking into account the above (rather narrow) list of assumptions, the predicted options are extremely broad.

On the videotex transaction forecast in Figure 12 -- which we believe is one of the most important indications from the user impact point of view -- the three different scenarios suggest that practically anything may happen. If one also took some additional factors, such as government support, user acceptance, pricing policy for competing services, etc., into consideration, the options would become even more diffuse. If one considered "third-generation videotex" systems the situation would become ever more complicated and the variety of options would increase even more. Is there an easy way to overcome these difficulties by traditional forecasting and modeling methods? Let us leave the answer to this question to the modelers.

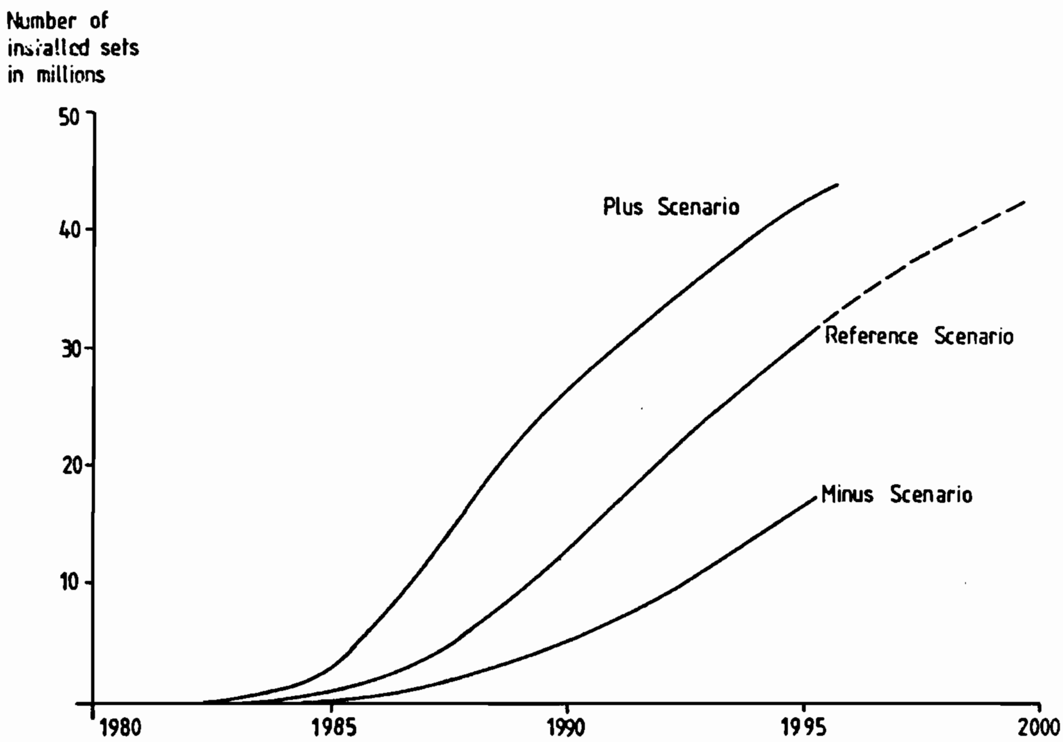

Figure 11. Videotex sets installed in the EEC [22]

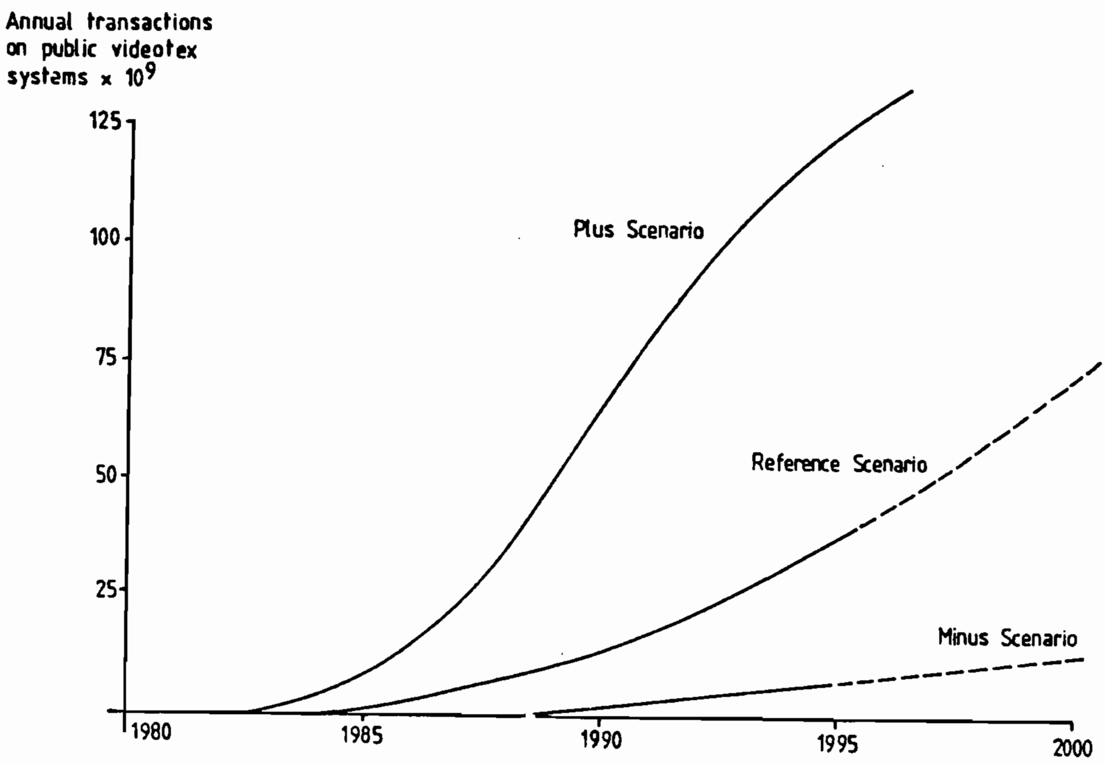

Figure 12. Videotex usage in the EEC [22]

Nonetheless, and here we are coming back to the line of thought followed at the beginning of this section, in spite of the potential diversity of videotex market penetration, there are certain physical limits which will constrain the market penetration of this new medium. One constraint, as pointed out, is the state of the telecommunications infrastructure and its potential development. If no proper telephone facilities are available in a country, then for a long time it would be unrealistic to plan a 2W videotex system based on the telephone network. Quite obvious...! For 1W narrow- or broad-band videotex a much faster market penetration could be achieved in principle since we believe that such a telecommunications infrastructure could be built within a decade or so. We would guess that the maximum speed of market penetration for these services would be similar to those of radio and TV if the long list of preconditions mentioned earlier are fulfilled. Thus between 15-20 years for full penetration will be required as a minimum. Electronics components such as microprocessors, personal computers, switching computers, videotex terminals, etc., do not seem to be limiting factors. A limiting or, better still, a slowing down factor could be the present telecommunications infrastructure in the developed countries, where massive previous investments (such as in the telephone network) have to bear their returns, negatively affecting, for example, the build-up of a new telecommunications infrastructure more suitable for certain videotex applications (such as the use of both cable TV or a dedicated satellite broadcast channel for 1WW videotex).

8. CONCLUSIONS

(1) As shown in Figure 13, after the present "first-generation" videotex systems based on 1WN (teletext) and 2W videotex, with simple numerical keypads and both with the main function of information retrieval, we are entering the phase of the "second-generation" 2W videotex systems with full alphabetical keyboards, gateway functions, and a wide range of applications which go significantly beyond simple information retrieval. Such applications include message sending, simple forms of transactions, simple computations through third-party computers, etc. In the foreseeable future we will witness the emergence of "third-generation" videotex systems which will be triggered off by the appearance of intelligent videotex decoders which will allow the concentration of more intelligence locally, taking the burden from the videotex network and third-party computers. The use of intelligent decoders will open the way to a broad range of new videotex applications, such as telesoftware, more sophisticated transactions, improved information retrieval functions, etc. The emergence of intelligent videotex decoders will enable full-channel (1WW) videotex systems be developed, where the amount of accessible information frames will grow by 3-4 orders of magnitude. With the present type of teletext decoders such large amounts of information cannot be handled, probably not even in the most rudimentary way, as is used in the present 1WN videotex systems. The main significant characteristic of "fourth-generation" videotex systems will be that the convergence of 1W and 2W videotex systems will be observed.

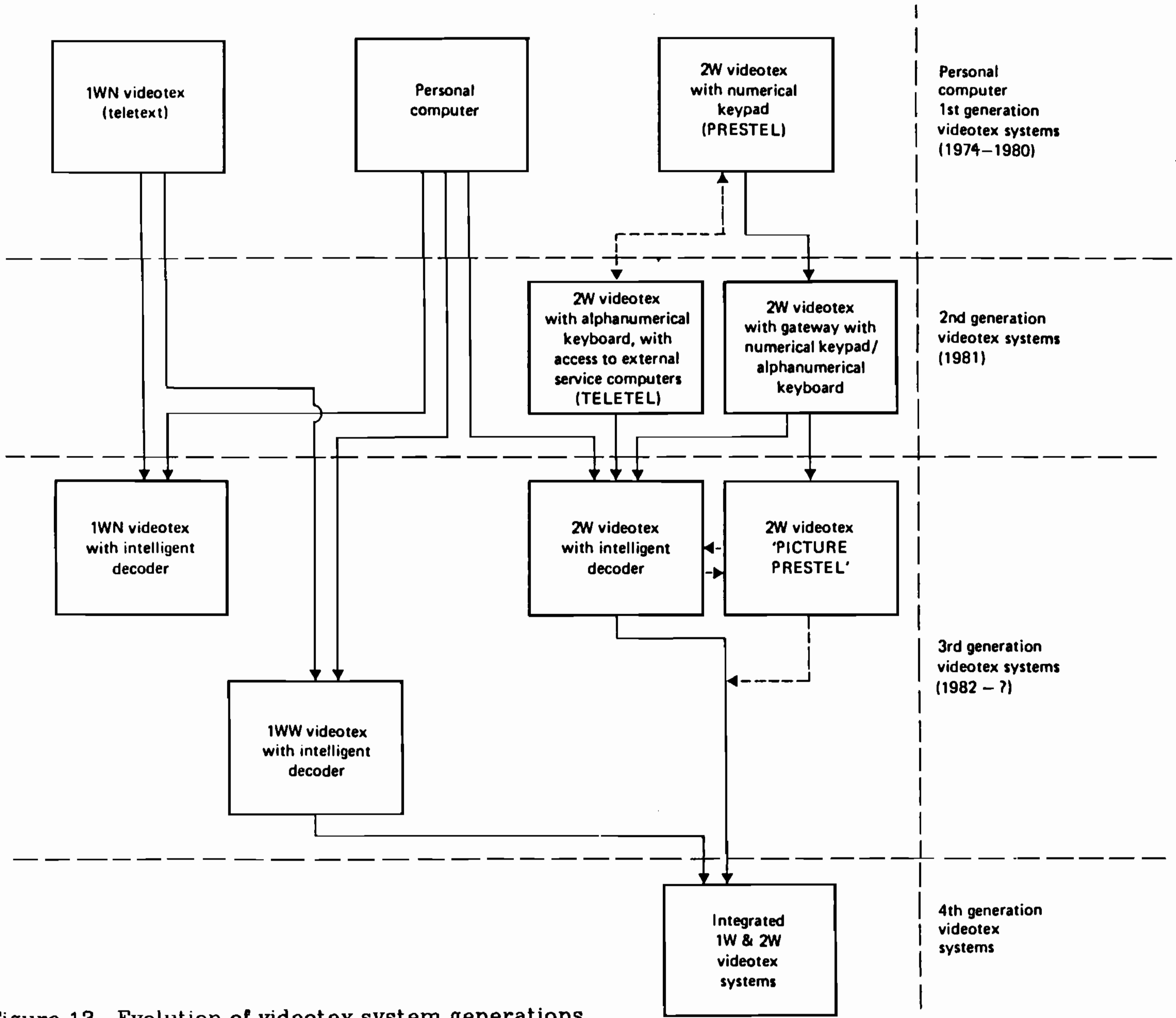

Figure 13. Evolution of videotex system generations

(2) The converging 1W and 2W videotex systems will not compete with each other. On the contrary, they will economize the widespread use of videotex services in a way that even mass applications of this technology will become feasible. In general, 1WN videotex systems will be seen primarily as supporting and upgrading the usual TV programs and, in addition, some information retrieval/distribution capabilities of very limited, general, or emerging nature. 1WW videotex (or full-channel teletext) systems are likely to emerge. Their information capacity of 50,000-100,000 rotating videotex frames will enable general, but broader information to be made available to the public and businesses, such as that provided by governments or local authorities. It can be expected that not only the information retrieval and message sending but also the educational use of such systems will become of major importance. Two-way videotex systems will be applied primarily in those areas where two-way interaction with a central computer is necessary. Message sending, teleshopping, financial and other types of transaction belong to this category, as well as access to time-sharing and other third party computers for computations and other real interactive applications. Two-way videotex will also continue to support information retrieval in those areas where access to information by the user community is relatively rare and it would be a waste of resources to put such information on "continuous" disposal, which is the case with 1W videotex systems.

(3) As to the implementation of 1WW videotex systems, two alternatives seem to be feasible at present: to use a dedicated cable TV channel, or to use a spare channel of a direct-broadcast satellite system. As to the choice of the above two telecommunications media, the state of cable TV infrastructure, future development plans, the availability of three direct-broadcast satellite system channels, and corresponding government policy will play a major role.

(4) The penetration of 1W and 2W videotex systems, can be summarized as follows. The microelectronics and information technology components will not be a barrier in the market penetration process. Both the videotex service computer as well as the terminal side can be satisfied according to the emerging demands. The state of the telecommunications infrastructure for a given country might become a barrier for future videotex systems. Historical statistics show that the development of a fully wired telecommunications infrastructure takes considerably longer than the build up of media based on broadcasting. Therefore, when creating national information and telecommunications policy concerning future 1W and 2W videotex systems, these factors have to be taken into consideration. Roughly speaking, one may say that for developing countries with little or no telecommunications infrastructure, it is better to put as much videotex service on the broadcast media as possible. For the developed countries with congested broadcast frequencies and well developed terrestrial infrastructures it is preferable to put 1W and 2W videotext on cable TV, the telephone, and the national packet-switching network.

(5) It can be expected that the penetration of videotex will take decades and will certainly be slower than either radio or TV. Factors such as information and telecommunications policy ("subsidize or not subsidize videotex, back it or not") will be of decisive importance. For this and other reasons we believe that it is most complex and difficult to predict the path of videotex penetration. As to the barriers of other kinds, such as organizational, legal, and human aspects of videotex penetration, further studies have to be undertaken.

(6) Finally, it is believed that 1W and 2W videotex systems will play a significant role in a future information-oriented society and we hope they will assist in overcoming some presently unsolved problems of society, such as the scarcity of energy and mineral resources, environmental pollution, urbanization problems, problems of food supply and industrialization, and finally, will improve the quality of life.

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APPENDIXES

APPENDIX A

Discussion

Summarized by Tibor Vasko

The discussion was very lively—any attempt to condense it in written form will certainly fail to reflect not only much of the meeting's working environment but also some of its essence. With this limitation in mind, I would like to summarize some of the thoughts expressed on the topics that appeared to be most pressing.

Early in the discussion, it was pointed out that it would be useful to consider three aspects of innovation in telecommunications: innovations arising from the manufacturer, i.e., the innovation of telecommunication technology *per se* (R & D, production and shipping of equipment); innovations adopted and incorporated by the PTTs (or RPOAs, common carriers) into their telecommunications systems and networks and their influence on the new services afforded; and the demand for innovations (acceptance or rejection) on the part of the user. It was noted that the complex relationships and interdependencies among these aspects seem to do more to impede rapid progress than to promote the desired development.

The manufacturers are proceeding very rapidly with innovation, for example in the application of LSI and VLSI circuits, optical fibers (Seetzen), satellite technique (Page), as they prepare equipment and methods for interconnecting telecommunications and computers. The level of R & D expenditures is important here and depends largely on the size of the manufacturer. Some of the new technologies are also opening up possibilities to smaller firms. These questions are being studied intensively in national research institutions.

It seems that the PTTs are very slow to accept innovative technology for a number of reasons: One is a lack of capital for investments—another is the barriers presented by regulation and standarization. Also, some new technologies have not yet achieved cost stability (Karttunen). And the present tariff policy has a substantial influence on the rate at which users are prepared to go in innovative ways in using telecommunications (Mueller).

The levels of the rates charged for telecommunications services is naturally bound with benefits to the users. Users, however, do not always know what kinds of performance the PTT can provide for them (Mueller).

The future performance of the PTTs will depend greatly on investment strategies (Seetzen). It would be very useful to acquire more knowledge in this area. In order to seriously study and compare the present state-of-the-art and forecasts of PTT performance in different countries, standardized measures are needed (Szentivanyi) or very minute analyses of statistical data with attention to differences in national data collection practices must be carried out.

User-related topics were brought up frequently during the discussion. The user often has no clear picture of what information he needs (Braun, Page) and its value to him (Braun). Within existing services the user is very often unaware of the performance level of the telecommunication services provided (Puzman). The fact that the concept of information and its value is ill-defined (Braun) prevents the use of many traditional economic concepts and methods. Information also has a culture-related aspect and a political value, however (Szentivanyi). On the other hand, new services (such as DDD--direct distance dialing) have a psychological impact on users which in turn affects behavioral patterns and relations to these services (Page)

Information technology is opening the door to several new possibilities. During the discussion, M. Meriams presented some notes on the "universal" university (see Part 2 of the appendix). His presentation met with great interest and stimulated a lively discussion. Most of the discussants agreed that new technology will bring new ways of learning and will contribute to a decline of the university in its present cultural context; i.e., learning may be partitioned in a different way (Seetzen). The trend may be toward a more interactive process, like that in Ancient Greece (Meriams). However, this idea was questioned by some (for example Braun, who pointed out the lack of student-to-student contact). Also, cultural and language difficulties may prove insurmountable. And the algorithm of using the best students to enhance the learning process (the "prima ballerina" concept) was seen as false.

The closing discussion summed up the main problems and formulated the most important questions for an international investigation in which we could hold an advantage. It was concluded that some issues could benefit even from an exchange of results and/or resulting cooperation.

The following were suggested as potentially rewarding issues suitable for future activities at IIASA:

- economies of switched networks in different countries (large vs. small countries; socialist vs. capitalist countries, etc.)
- integration of telecommunication devices and services (for example in office automation)
- costs and tariffs vs. information benefits and their balance
- transborder data flows, especially within Europe where practices are particularly varied
- PTT-user-manufacturer relations in different countries
- telecommunications in developing countries and their role in strategies for development

The participants expressed the opinion that IIASA could play an important role in an exchange of knowledge about these issues among researchers in different countries.

APPENDIX B

Notes for Discussion

by Miles L. Meriams
International Institute for Applied Systems Analysis

The Truly "Universal" University: An Innovation in Education, made possible by Information Technology

The modern University can hardly be called that; it is neither truly modern nor universal. In fact, the University has been one of the more stable of our social institutions, virtually unchanged in form and function since its inception in the 12th and 13th centuries [1]. There have of course been recent timid rumblings of change, as exemplified by the Open University in the U.K. [2], but these have been primarily driven by social pressures rather than being responses to the opportunities—and challenges—presented by technology. One factor contributing to this stability is the Universities' geographical linkage to repositories of knowledge; to libraries. Another factor is the requirement for the tutor and the tutored to be physically in each other's presence. But these linkage can now be broken, using the technological sledgehammers now, or soon to be, available. Electronic presence can substitute for physical presence. It is now possible to consider establishing a "University" with no fixed place of domicile. Students could be scattered throughout the world, individually or in small groups. Courses could originate from almost any point in the globe, depending on subject matter and availability of expertise. Classes would be fully interactive, using-full motion television, document delivery systems, and electronic blackboards. Libraries throughout the entire world could be referenced and used.

It is not the purpose of these notes to discuss the technology which makes this innovation possible; technology which will in any event be familiar to most of us present. The purpose is rather to stimulate consideration, by a knowledgeable and concerned audience, of the effects of using technology in this manner. What will be the advantages or drawbacks to establishing a truly Global University? What problems must be overcome? What areas will be most affected? Sooner or later the Academic and Scientific community will be called upon to advise on, or assist in establishment of, such a University, for when a potential exists there is always an impetus to realize it. (A corollary to Murphy's Law might well be: "If something is possible, someone will try it; even if it is impossible.") It is, therefore, not too early to start thinking about the subject. These brief notes represent some preliminary thoughts; I trust they will be effective in promoting an exchange of ideas. Comments would be most welcome.

ADVANTAGES OF A GLOBAL UNIVERSITY

- The best and most stimulating teaching would reach the widest possible student body. Subject matter of only limited interest in one geographical area, or in which a limited number of qualified professors exist throughout the world, would be available to all students.
- It is consistent with the trend towards viewing education as a continuing process, rather than as a phase which one passes through at a set age, with a structured approach and the objective of obtaining a specific qualification.
- By increasing intercultural contact, and exposing students (and teachers!) to what is best in other cultures, it may contribute towards lessening of international distrust and tension.
- It could be structured to provide opportunies for unscheduled "impulse" learning by drop-in, non-interactive, individuals.

DISADVANTAGES OF A GLOBAL UNIVERSITY

- The demand for, and workload imposed on, exceptional teachers may become excessive.
- Established Universities may feel threatened by erosion of their student body and status.
- It may create a potential for conflict, due to perceived control of the University by one country or group of countries.
- Cost and administrative effort may be more productively employed along traditional lines.

POSSIBLE PROBLEM AREAS, OR ASPECTS REQUIRING CLARIFICATION

- How will the curriculum be set, faculty appointed, student achievement be confirmed, etc.
- Shall the Global University grant degrees? How and where will they be honored?
- What linkage shall be established with other institutions in order to provide facilities for practical or laboratory work?
- Policy on research and publications. (In this regard it should be pointed out that Computer Based Conferencing Systems have already demonstrated their value in supporting research by widely dispersed groups of scientists. The technique will greatly facilitate research at a Global University.)
- Financial considerations, fees, salaries, payment for technical facilities, etc.
- Administrative Support requirement.

- Arrangements with telecommunications authorities to provide transmission facilities and technical support.

MECHANISM FOR ESTABLISHING A GLOBAL UNIVERSITY

A decision must be made as to whether it shall be set up under the aegis of an existing international body such as UNESCO, or whether a new international body should be created for the purpose. There is also the possibility of initial joint action by a small group of countries, with provision for other countries to affiliate themselves later on. (The approach used to establish the INTELSAT system, providing public international satellite communications, may be a useful guide in this case.)

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APPENDIX C

The Agenda

MONDAY, MARCH 29

10:00–11:30	Presentation of Papers
	T. Vasko (IIASA-Czechoslovakia): Telecommunications: The Issues
	I. Sebestyen (IIASA-Hungary): One-Way Versus Two-Way Videotex
	J. Puzmann (Czechoslovakia): The Credits and Debits in Telecommunications
11:30–11:45	Coffee Break
11:45–13:00	Presentation of Papers (Continued)
13:00–14:00	Lunch
14:00–15:00	Travel to the Exposition
15:00–15:30	Introduction to the Tour (Given By G. Kovacs--Deputy Director of SZKI)
15:30–17:30	Guided Tour of Exposition "Computers for Everybody" organized by Janos Neumann Society
17:30–18:30	Return to Hotel Szamok
19:00	Reception in the Szamok Bar

TUESDAY, MARCH 30

9:00–11:00	Presentation of Papers
	S. Karttunen (Finland): Telecommunications Support The Printing Industry (A Case Study of the Latest Developments in Finland)
	O. Grandstrand (Sweden): Financing A New Technological Investment: A Case Study In Telecommunications
	J. Page (IIASA-UK): Conflicts in Telecommunications Policy and Innovation in Information
	P. Nemeth (Hungary): View Data Systems for Inventory Control

11:00–11-30	Coffee Break
11:30–13:00	Presentation of Papers (Continued)
13:00–14:00	Lunch
14:00–14:30	Visit to "SZAMOK" (Institute for Educating Managers in the Use of Computers)
14:30–18:30	Sightseeing Tour of the City
18:30	Hungarian Restaurant with Music

WEDNESDAY, MARCH 31

9:00–11:00	Presentation of Papers, Discussion, Recommendations
	E. Braun (UK): The Value of Information
	M. Merians (IIASA-USA): Notes for a Discussion-Possibility of Establishing a "Global" University
	J. Mueller (FRG): The Role of the PTT in Telecommunications
	J. Seetzen (FRG):
11:00–11:30	Coffee Break
11:30–13:00	Presentation of Papers, Discussion, Recommendations (Continued)
13:00–14:00	Lunch
Rest of Afternoon	Free
Evening	Departure

APPENDIX D

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