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ONE-WAY VERSUS TWO-WAY VIDEOTEX

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ABSTRACT

One-way and two-way videotex are often claimed to be more or less competing services, particularly if dedicated channels are used for the broadcast variety. In this paper we will try to dispel this notion. We will try to demonstrate that not only are the two services somewhat complementary in nature but that videotex will increase its potential by choosing a balanced combination of the two services. We also study the likely market penetration of videotex based on the speed of penetration of other communications-oriented services in the past and draw some conclusions how they might influence the market penetration of videotex systems and services.

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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)	155	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 (2.5 GHz)	$1-5,000
TDF-1,TV-SAT 36 (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	6	$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	26	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.

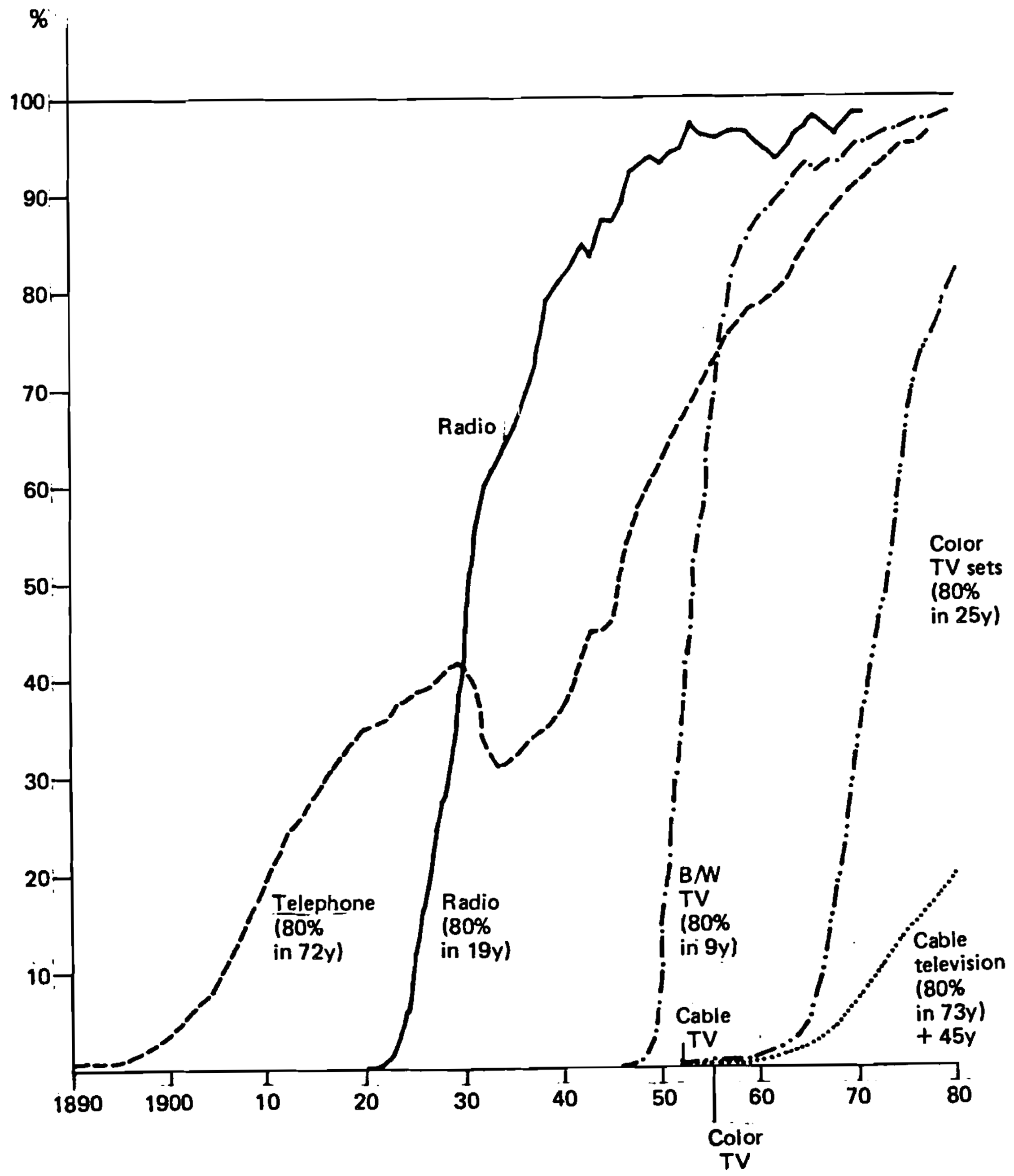

Figure 2 Penetration of households with telephone, radio, TV sets in the USA (%) [23, 24]

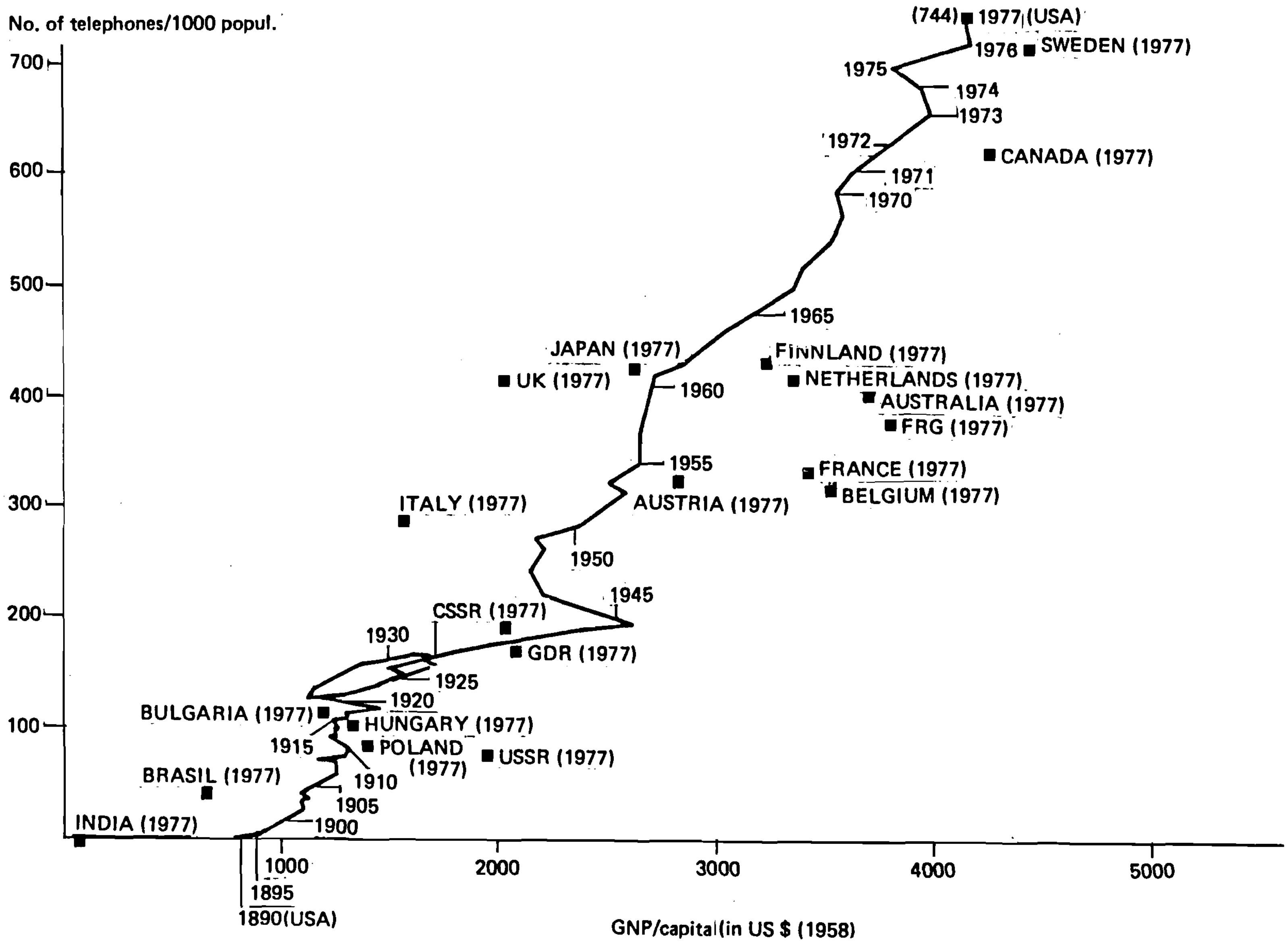

Figure 3 Number of telephone per 1,000 population in 1977 for selected countries and for the USA between 1890 and 1977 [22, 23, 26]

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

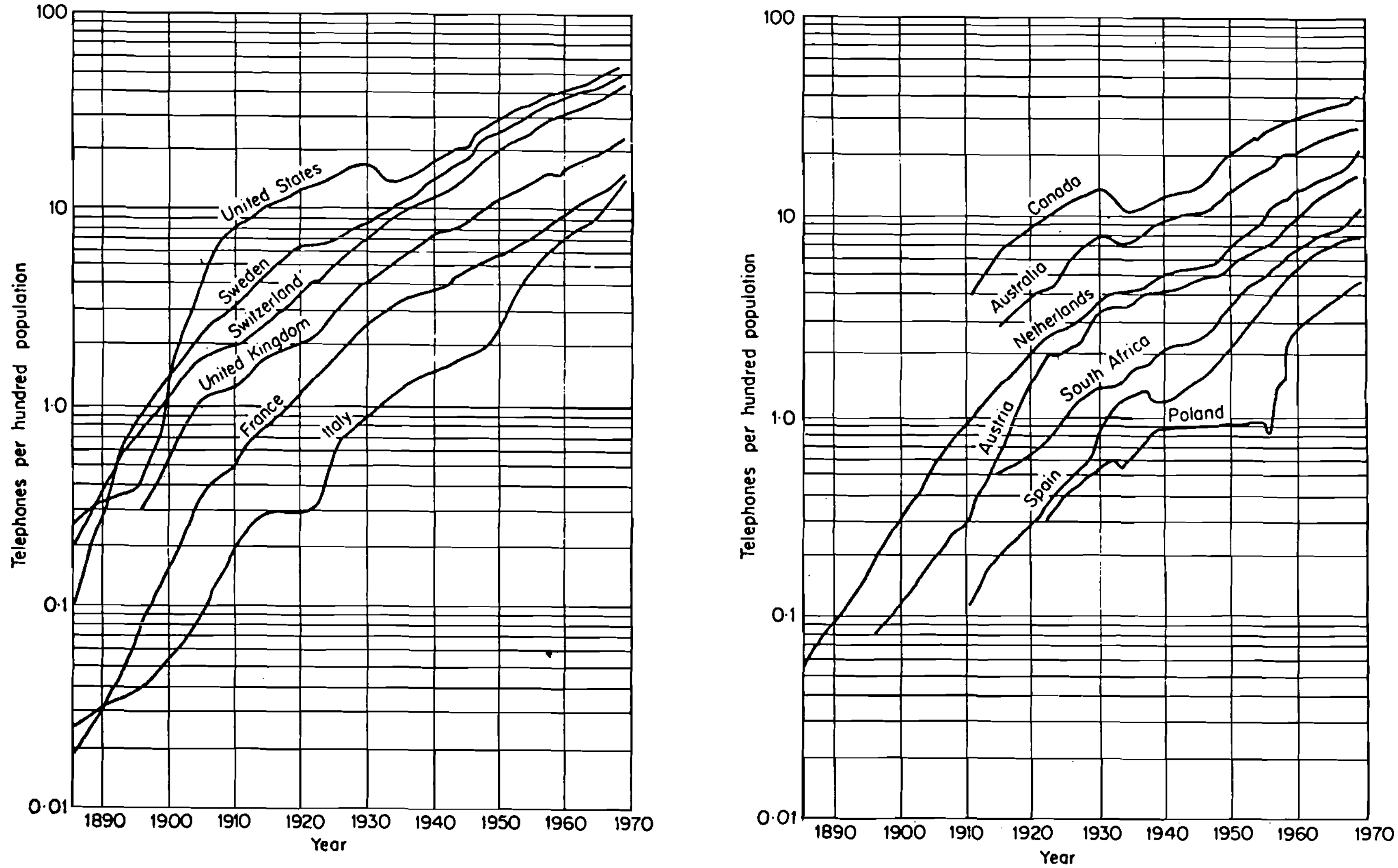

Figure 4 a and b Telephones (stations) per 100 population in various countries (Groups A and B) [25].

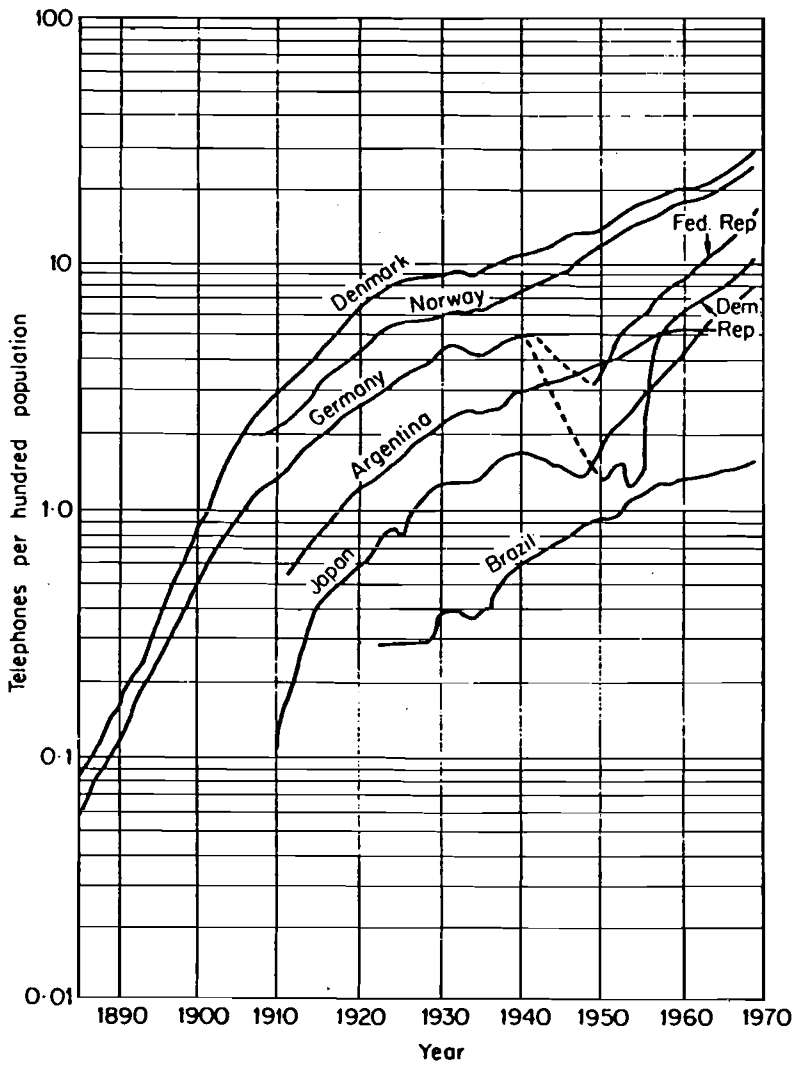

Figure 4c Telephones (stations) per 100 population in various countries (Group C) [25].

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

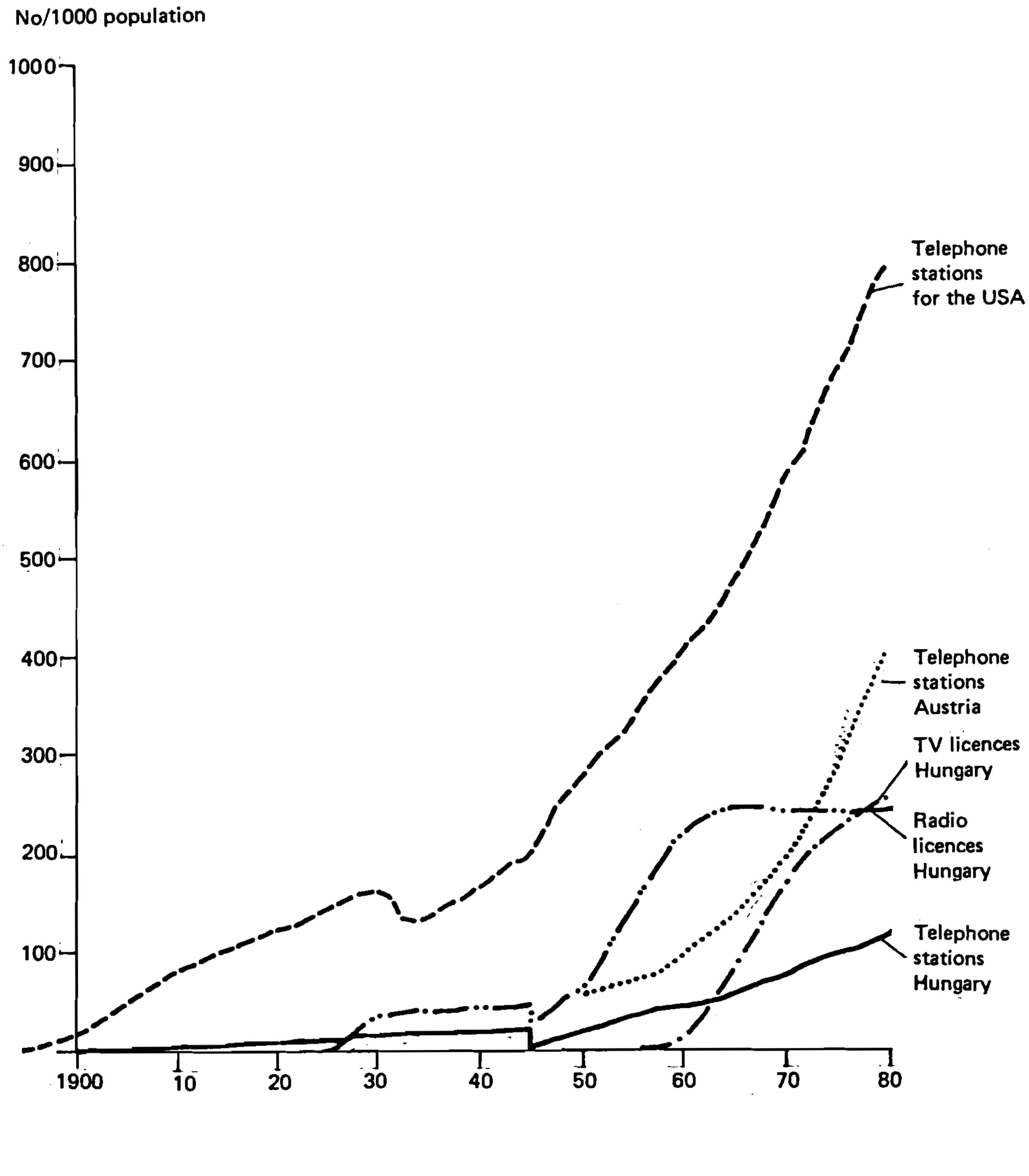

Figure 5 Number of TV/radio licenses and telephone stations per 1,000 population in Hungary [30, 33]

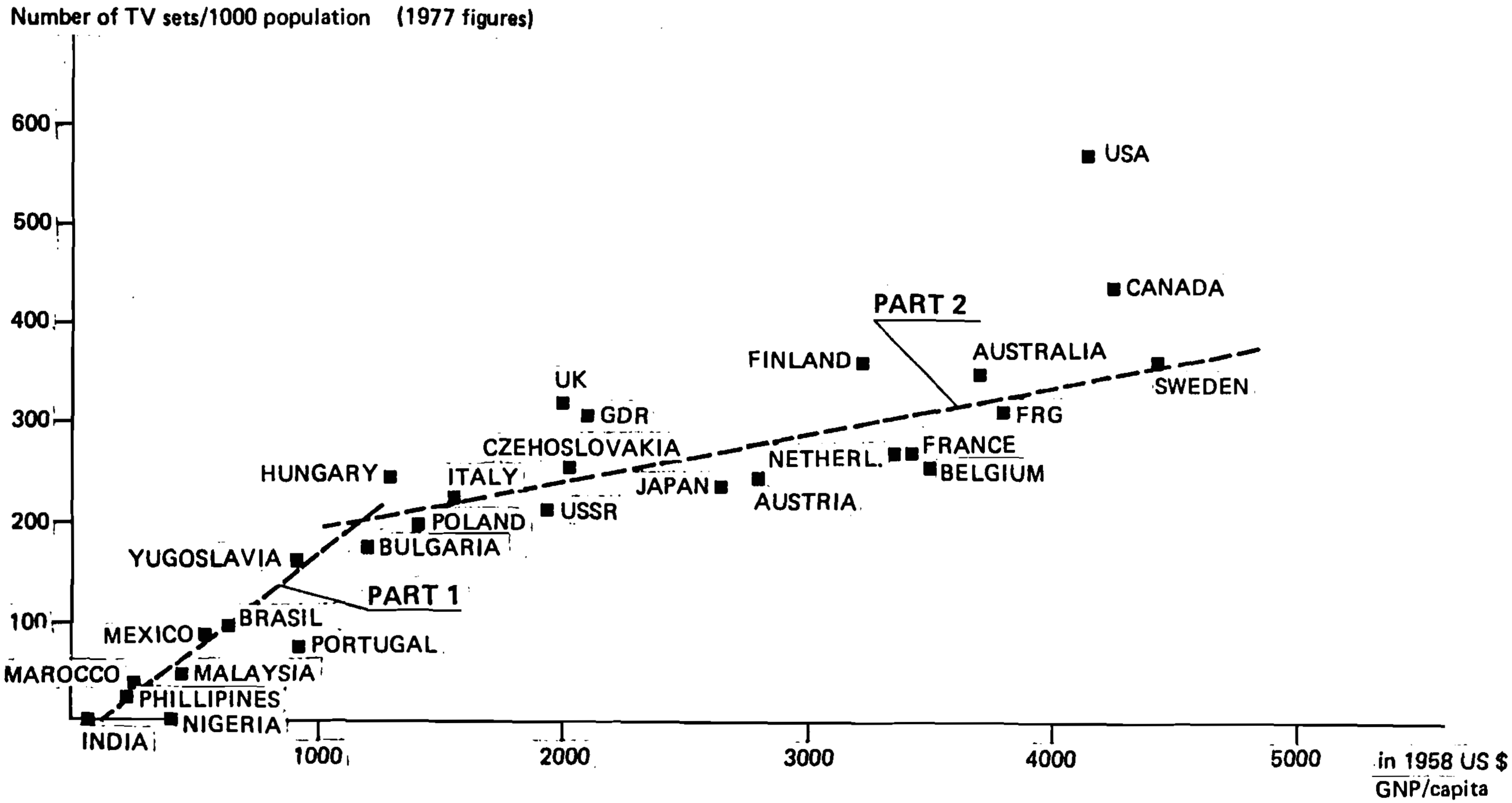

Figure 6 Number of TV sets per 1000 population in selected countries according to 1977 figures

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

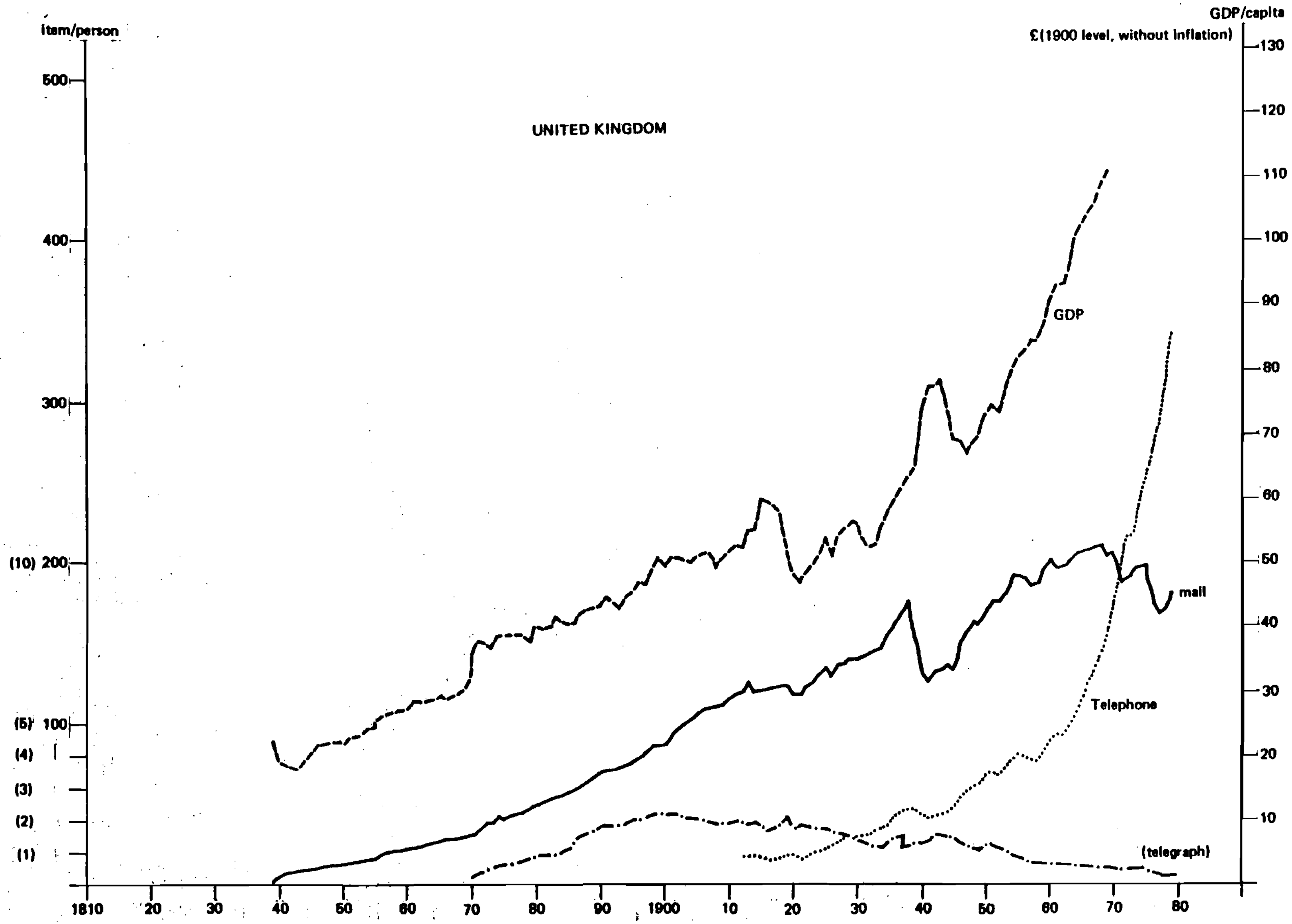

Figure 7 GDP per capita curve and number of mail, telephone calls, telegraph messages per person in the UK, 1840-1980 [27, 28].

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

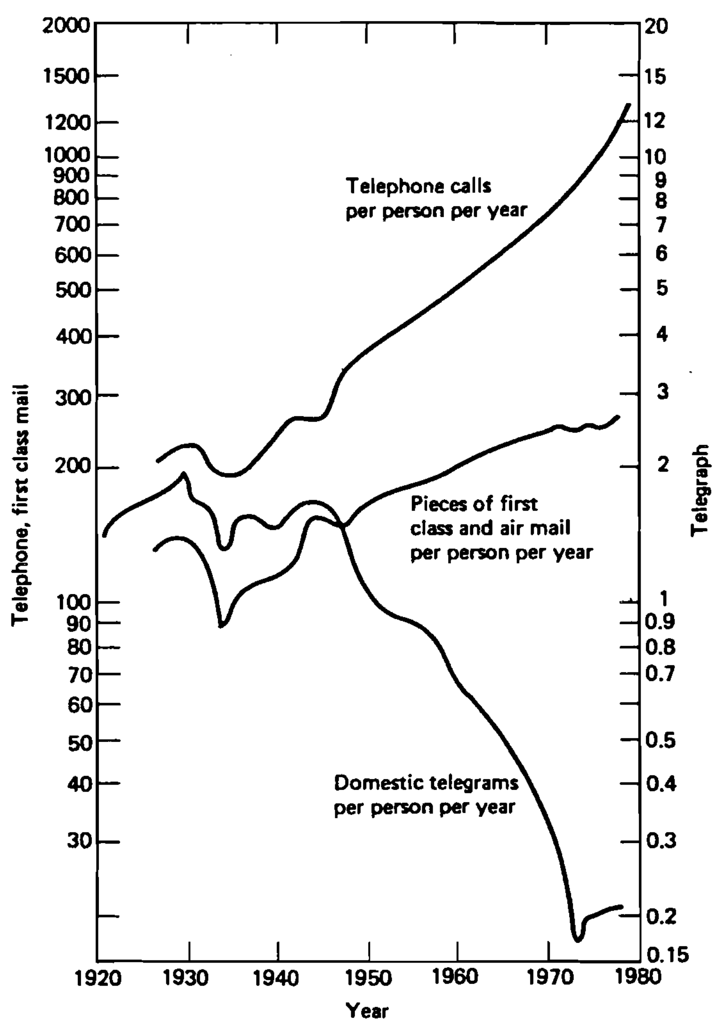

Figure 8 Number of telephone calls, pieces of first class mail and air-mail, and telegrams per persons per year in the US [23, 24]

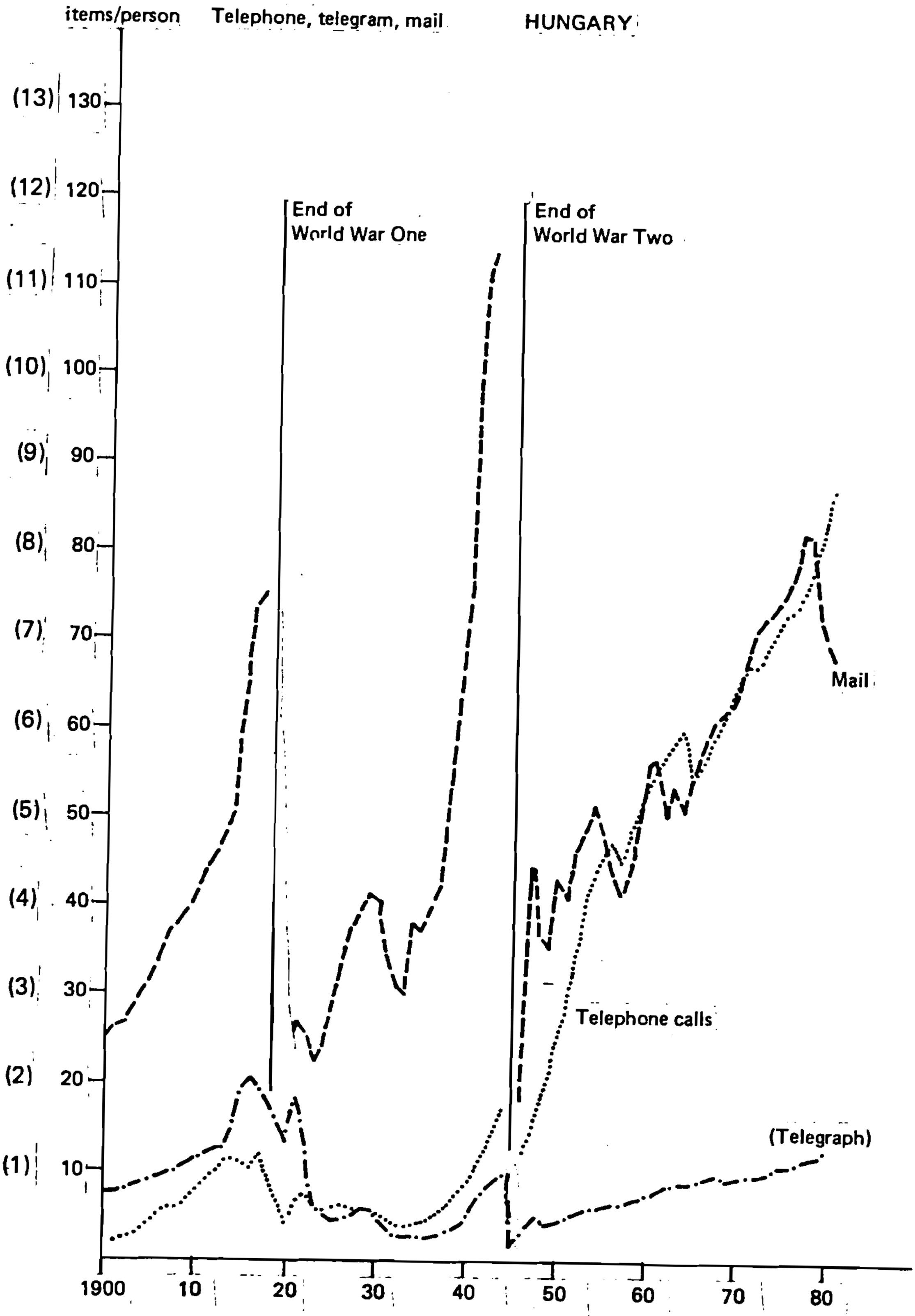

Figure 9 Number of mail, telephone calls, telegraph messages sent per person in Hungary between 1900 and 1980 [27, 28]

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]	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	1948-66	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., narrowband 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.

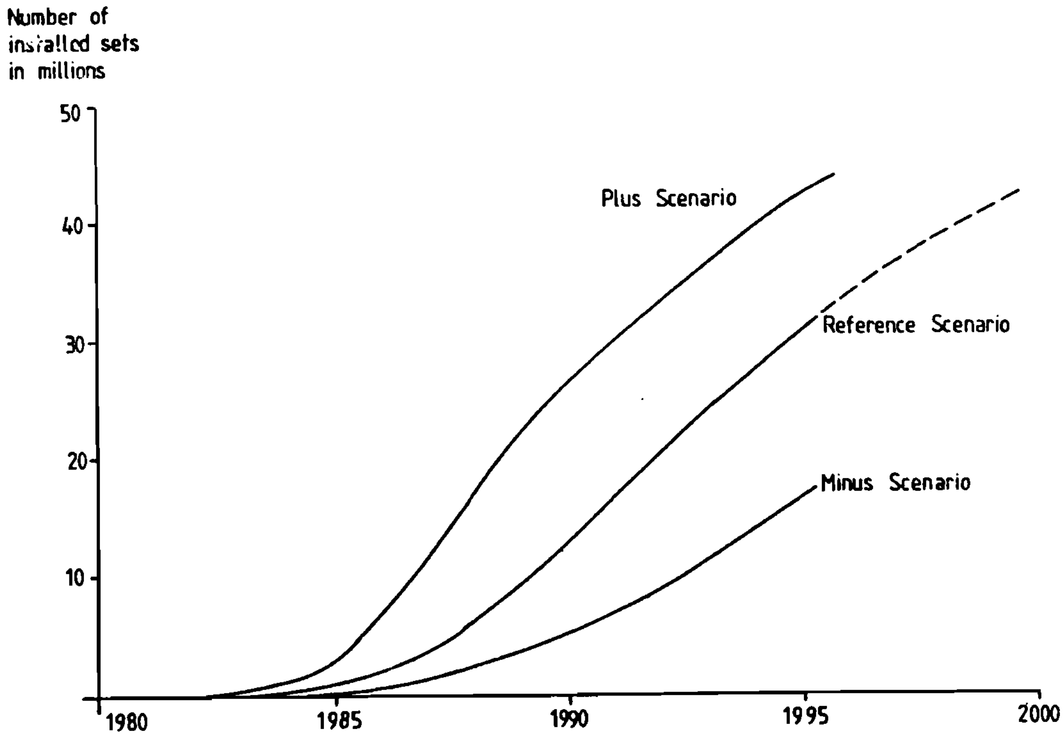

Figure 11. Videotex sets installed in the EEC [22]

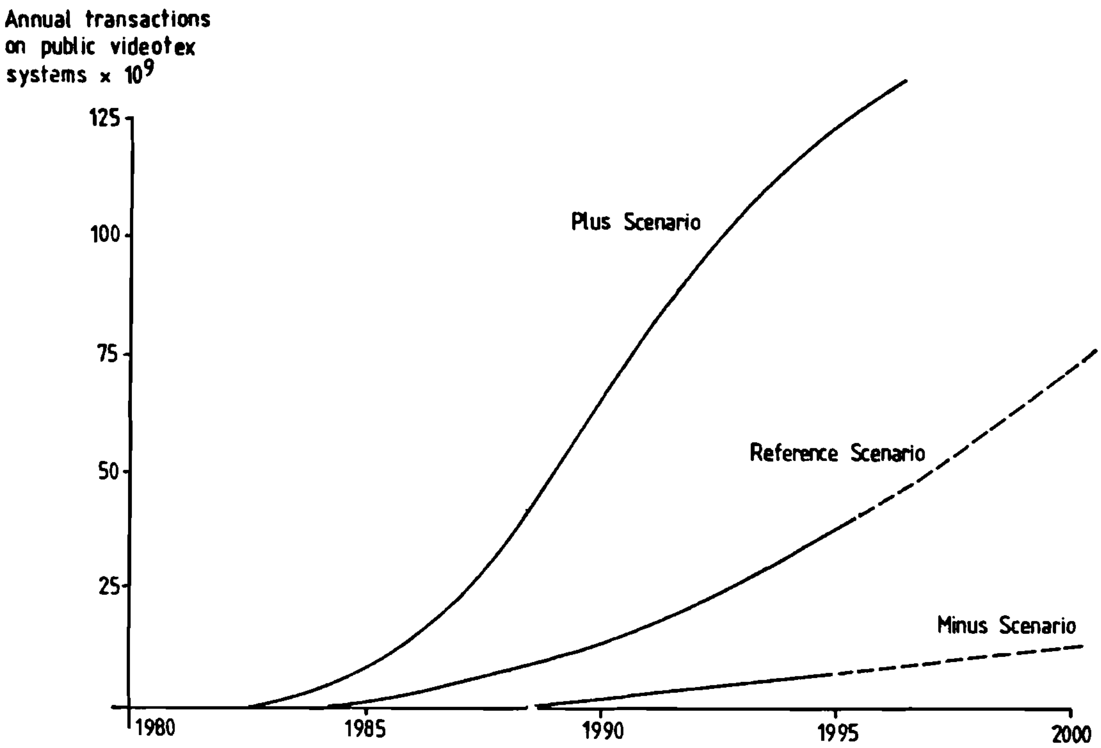

Figure 12. Videotex usage in the EEC [22]

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.

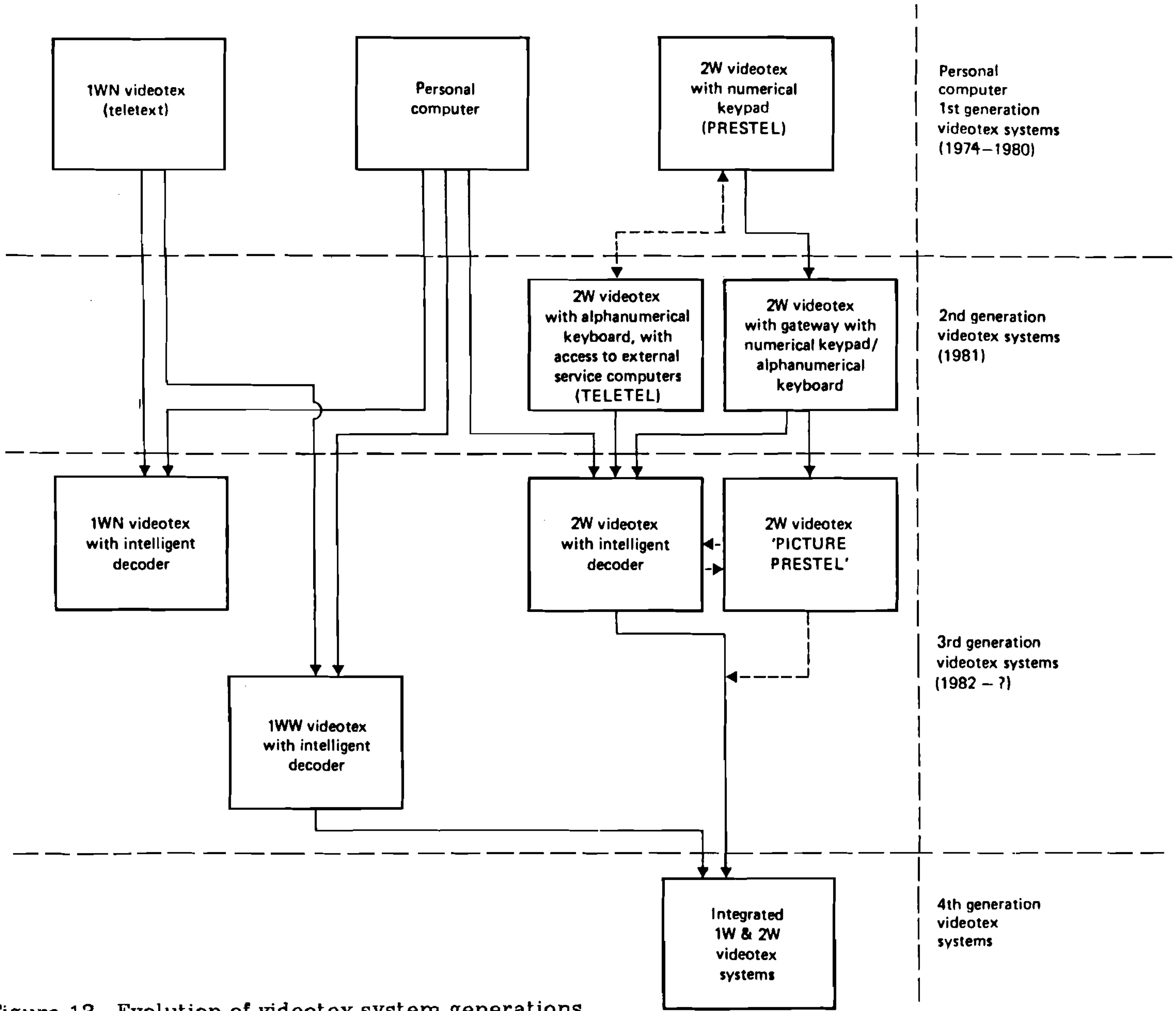

Figure 13. Evolution of videotex system generations

(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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