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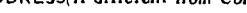
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VIDEO TELECONFERENCING:
CONFERENCE MODE OF THE FUTURE

by

Stanley Earl Snead

B.S., N.W. Missouri State College, 1969

and

Leslie Howard Duncan

B.S., Wichita State University, 1970

M.B.A., University of Alaska, 1977

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and

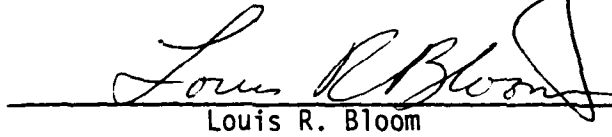
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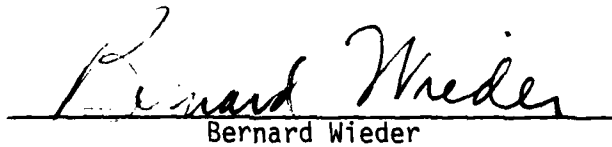
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by


S.W. Maley


Louis R. Bloom


Bernard Wieder

Date 6 August 1979

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Snead, Stanley Earl (M.S., Program in Telecommunications)

and

Duncan, Leslie Howard (M.S., Program in Telecommunications)

Video Teleconferencing: Conference Mode of the Future

Project directed by Professor S.W. Maley

Although video teleconference systems have been used, on a limited basis, for more than a decade, they have not yet achieved widespread popularity. This is due, primarily, to the traditionally high costs of video teleconference equipment and broadband transmission links and the traditionally low costs of fuel and transportation. The stigma created by the failure of AT&T's Picturephone, human factors, and the fact that it is not possible to purchase a video teleconference system package from a single vendor have also contributed to the slow growth of these systems.

Recently, these traditional barriers have shown signs of lifting, and indications are now that widespread usage of video teleconferencing in lieu of travel is just around the corner. This paper examines the viability of video teleconferencing, both now and in the future, in light of recent events and current trends.

First, the evolution and development of video teleconferencing is traced, from the first video telephone which was demonstrated in 1927 to the full-feature, color systems available today. The competing and complementing roles of communication satellites, fiber optics, bandwidth compression techniques, interactive cable television, video cassette recorders, and large projection video screens are discussed. The human aspects of designing and implementing a video teleconference system are also considered. In addition, the

potential benefits and impacts of video teleconferencing on the energy crisis, air pollution, medical and educational systems, and the deaf are presented.

Central to this study are two original cost analysis methods, designed to serve as a model for business and government managers who wish to evaluate the potential cost-effectiveness of video teleconference/travel substitution within their organizations. One method can be used to evaluate the potential cost effectiveness of an off-premise, studio system such as AT&T's Picturephone Meeting Service; the other method is designed to determine the potential cost-effectiveness of a privately-owned, on-premise studio system.

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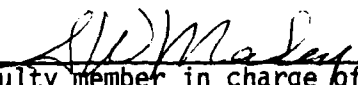

Faculty member in charge of project

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CHAPTER I

INTRODUCTION

The telephone brought a new dimension to human communications. Where previously men had been able to send written messages over wires as electrical signals, the telephone made it possible for the human voice to span the miles. Now, more than 100 years later, the telephone is commonplace and another dimension has been added -- that of sight. Video teleconferencing, the name generally given to sight and sound systems, has not, as yet, achieved wide spread acceptance, but many experts believe that this will change in the very near future. One expert predicts that there will be 300 to 500 video teleconference systems in use in this country alone by the mid-1980's. The same source estimates that fewer than 50 such systems are in use today.

Growth of video teleconferencing will be due, in part, to its potential to solve many crucial business and social problems. We are currently in the midst of a very real and critical worldwide energy crisis. The shortage of fossil fuels has already driven the price of gasoline, diesel and jet fuels to all time highs, and increased the entire world's dependence on foreign crude oil sources. At the same time, the increased use of transportation, has caused serious air pollution problems for many of our major cities. The potential of video teleconference systems to substitute for conventional travel offers a possible solution to these business,

social, and economic problems. In addition, video teleconferencing has the potential to benefit local and national government, medical, and educational systems. The added dimension of sight will also greatly aid members of the deaf community. In short, there is much to be gained from this new telecommunication technology.

Video teleconference systems, and their potential benefits, have been examined before. However, past analyses have failed to focus on a particular system for a particular service. Further, most of these analyses were compiled in the early to mid-1970's. In addition, past studies have been largely inconclusive. One recent writer said that, while there is already a significant body of literature on the subject of video teleconferencing, "a great deal of it is reiterative and most of it is highly speculative."¹

Video Teleconferencing Defined

Before we go any further, we would like to pause to define the term video teleconferencing. For the purposes of this paper, video teleconferencing will be defined as a telecommunications service which allows the simultaneous transmission of two-way audio and visual information. Included in the category of visual information are such things as texts, graphics, 35 mm slides, and both still and moving pictures. Excluded in our definition are CRT based computer teleconference systems which are used exclusively for computer teleconferencing (although these systems are discussed briefly in Chapter III). There is certainly no reason, however, why the CRT which is used for video teleconferencing under our definition cannot be used to display computer information as well. Also excluded in our definition

are one-way video, interactive cable television systems (also discussed briefly in Chapter III), and audio-only systems.

Based upon our definition, video teleconference systems can be grouped into three basic categories: telefacsimile, slow scan video, and fully animated video. Telefacsimile provides the first step above the audio-only teleconference mode, by adding the capability to transmit graphics to conference participants. Telefacsimile can be transmitted over ordinary telephone lines, however, simultaneous audio and graphic transmission requires two separate telephone wire pairs. Slow scan video systems are capable of transmitting a still picture of anything within the field of view of a video camera. A slow scan converter translates the video information to an audio frequency for transmission over normal telephone lines. Thus, the cost of slow scan systems is considerably less than that of fully animated systems. Animated video systems offer the ultimate in video teleconference systems; the capability to transmit moving video images as well as sound. Unlike telefacsimile and slow scan systems, however, the signals of fully animated systems cannot be transmitted over normal telephone wire pairs. The cost of animated systems is therefore much higher.

The telefacsimile, slow scan, and animated classifications discussed above are certainly not the only categories in which video teleconference systems can be grouped. Table I lists the various types of classifications which can be applied to video teleconferencing. As we shall see in the next chapter, every one of these characteristics has manifested itself over the course of video teleconference development.

TABLE I
METHODS OF CLASSIFYING VIDEO TELECONFERENCE SYSTEMS

Mode:

Slow Scan
Fully Animated
Telefacsimile

Network Configuration:

Point to Point
Multi-location
Switched

Equipment Used:

Video Telephone
CCTV

Location of Equipment:

On-premise
Off-premise
Desk top
Studio-based

Transmission Media Used:

Satellite
Microwave
Coax Cable
Fiber Optics
Broadcast, etc.

The purpose of this paper is to explore the evolution, human aspects, potential economic and social implications, and the future of video teleconferencing. Chapter II traces the history and evolution of video teleconference systems. Chapter III will look at the technologies which have and will work to reduce costs and improve the effectiveness of video teleconferencing. In Chapter IV, the human factors of video teleconferencing are considered. Chapter V will study the potential substitutibility of video teleconferencing for business and government travel. Chapter VI will be devoted to a brief discussion of the social benefits of video teleconference systems. Finally, Chapter VII will look at video teleconference systems of the future.

FOOTNOTES

1. National Transportation Policy Study Commission, The Impact of Telecommunications on Transportation Demand Through the Year 2000, NTPSC Special Report No. 3, November 1978, pp. 67, 76.
2. Ibid., p. 13.

CHAPTER II

THE HISTORY OF VIDEO TELECONFERENCING

The Evolution of Video Teleconferencing

The first video teleconference took place on April 7, 1927 when Secretary of Commerce Herbert Hoover and other officials in Washington, D.C. spoke face-to-face with Walter S. Gifford, President of AT&T, and other Bell System officials in New York City.¹ From this time until the early 1970's, video teleconference systems were almost exclusively video telephone systems, largely because AT&T, the leader in video teleconference development, had their eye on a potentially huge video telephone market. The Bell System brought the video telephone through several distinct evolutionary stages between 1927 and 1969. Their work, which culminated with the introduction of the Picturephone² in 1965 and 1968, provided the foundation and the catalyst for present-day video teleconference systems.

Picturephone Development

Between 1927 and 1956, Bell Laboratory engineers developed several versions of video telephones, varying in size, appearance, and quality. On August 23, 1956, they demonstrated their most advanced system before the Institute of Radio Engineers. By today's standards, this early model was crude and inadequate. The camera,

video display, display screen, and telephone instrument were all separate desk top components, and the screen was circular, less than three inches in diameter. Experiments conducted in 1957 allowed AT&T to reduce costs, while, at the same time, improving such picture standards as resolution and contrast. In 1959, plans were made to develop a complete video telephone system. In 1963, this system was unveiled, and in 1964, it was demonstrated to the public at the New York World's Fair and at Disneyland. Between 1964 and 1965 improvements were made, based upon comments received at these public demonstrations and on limited service trials in New York, Chicago, and Washington, D.C. These improvements made, the Bell System introduced the Picturephone in 1965.³

Picturephone Mod I

The first Picturephone, Picturephone Mod I, had a nominal 500 kHz bandwidth.⁴ The equipment consisted of three packages: a display unit, a special telephone, and a power supply. The display unit contained an oval shaped cathode-ray picture tube, a vidicon camera tube, the scanning, synchronization, and other video circuits and a loud speaker. Besides a conventional, black telephone, the telephone unit contained a microphone (to permit handsfree answer back), a set of Touch-Tone⁵ pushbuttons, and pushbuttons for video control.⁶

Picturephone Mod I was test marketed for a total of four years, during which time nearly 800 persons evaluated its utility and features.⁷ In addition to the 1964 World's Fair and Disneyland exhibits already mentioned, tests were conducted between Bell Laboratory locations at Murray Hill and Holmdel in April 1965 and between the

Union Carbide Corporation, New York Telephone Company, Illinois Bell Telephone Company, and AT&T in July 1965. Other smaller scale tests were also conducted. The tests were designed to determine three things:

- (1) how users would react to the design, features, and operation of Picturephone service;
- (2) whether users could stay on camera; and
- (3) whether there was a potential market for the video telephone.⁸

Picturephone Mod II

As a result of the comments received during the four years of Picturephone Mod I testing, a completely new video telephone, known as Picturephone Mod II, was designed. The new system consisted of a 12-button Touch-Tone telephone; a display unit with a built-in picture tube, camera tube, and a loudspeaker; a control unit which contained a microphone; and a service unit which contained a power supply, logic circuits, and transmission equalizing circuits. The Touch-Tone telephone, the display unit, and the control unit were all desk top mounted. The service unit was installed out of sight.⁹

The picture signal was composed of 250 active lines displayed on a screen 5-1/2 inches tall and 5 inches wide.¹⁰ In contrast, a broadcast television signal is composed of 485 active lines displayed on a screen which is generally much larger.¹¹ Picturephone, however, did retain a 30/sec frame rate, and the interlace of frames as on broadcast television. Normally, a person using the Picturephone would have been about 36 inches from the screen. The field of view, at this distance, was adjustable from 17-1/2 by 16 inches to 28-1/2

by 26 inches to allow the user to move from side to side during his conversation. The system required a transmission bandwidth of 1 MHz as compared to the 4.6 MHz bandwidth required for broadcast television.¹²

To initiate a Picturephone call, the user simply pressed a designated button on the Touch-Tone telephone pad, and, in most cases, dialed the regular telephone number of the person he was calling. A distinctive ring, created by a new tone generator, identified an incoming Picturephone call. Additionally, if the recipient had a key telephone instrument, the button corresponding to the incoming Picturephone call would light up red as opposed to lighting white for voice-only calls.¹³

Picturephones were connected to local central offices by a six-wire loop. One pair of wires carried the voice portion of the signal, which was switched conventionally through the central office. The video portion of the signal was switched by a specially designed four-wire video switch.¹⁴ For distances of six miles or less, Picturephone signals were transmitted and switched in analog form; for transmission beyond six miles, the entire signal, video and audio, was digitally encoded using differentiated pulse code modulation.¹⁵

Picturephone could do much more than simply allow one to see the person to whom he was speaking. For instance, the Picturephone could communicate with a commercial computer via the Touch-Tone pad on the telephone. The information retrieved or the results of a computation were displayed on the Picturephone screen.¹⁶ By setting the camera focus to one-foot, the system could be used to transmit

text and graphics,¹⁷ although admittedly, the resolution and quality of graphic transmissions were very poor, and the field of view could not accomodate the standard business letter.¹⁸ The system had a self-view button which allowed the person talking to look at himself as he was being seen, as well as an exclusion button which prevented the person at the other end from seeing who he was speaking with. Theoretically, a zoom lens on the camera allowed as many as three people to be on camera at the same time,¹⁹ however, it is difficult to imagine the utility of this feature given a 5-1/2 by 5 inch screen.

Unlike Picturephone Mod I, the product trial for Mod II was very short. In February 1969, 41 sets were installed in the offices of the Westinghouse Electric Company in Pittsburgh and New York.²⁰ Westinghouse was chosen because it had a complex intracompany phone system which could handle Picturephone circuits and because the company had major offices in Pittsburgh and New York which made it suitable for long distance service tests.²¹ Westinghouse officials were impressed. Westinghouse Chairman, Mr. Donald C. Burnham, was especially pleased, and he praised Picturephone highly for its potential as a travel substitute. He stated that he, personally, made much fewer trips between Pittsburgh and New York while Picturephone was installed, and he estimated that the service could eliminate about 20% of all of Westinghouse's out-of-town business trips.²² Based upon the favorable outcome of the Westinghouse test, AT&T decided to sell Picturephone service to the public.

They launched their marketing campaign with great fanfare and many glorious predictions. The Picturephone was hailed as a

tremendous stride forward in telecommunications technology, which many Bell System officials considered to be equal in magnitude to Alexander Graham Bell's invention of the telephone itself.²³

Initial service was scheduled to begin July 1, 1970. Although this initial offering would be limited to a 70 square block area in downtown Pittsburgh, AT&T predicted that it would expand the service to seven other Northeastern cities by 1973, and have long distance service available at about the same time.²⁴ AT&T predicted further that by 1975 more than 100,000 Picturephones would be in use, mostly in the business community, and that Picturephone would gain wide acceptance in the home by the 1980's.²⁵ In 1971, when Picturephone service was introduced in Chicago, Illinois Bell ran a full page ad in the Chicago Tribune which began, "We're looking for 500 businessmen who want to start a revolution." The text of the advertisement emphasized Picturephone's usefulness for "all kinds of visual material" and concluded with, "Picturephone communication. Business will never be the same."²⁶

Not everyone was as enthusiastic about Picturephone as AT&T. Patrick Ryan, a writer for the American Scientist Magazine said this:

Indomitable telecommunicationists fever their brains to create ever-swifter means of world communication; recking not about the existing pace of global question-and-answer which already surfeits of coronary thromboses, nervous tics, and rich ulcers. And now, without pausing to consider whether anybody actually wants it, they have proudly developed the Picturephone.²⁷

For whatever reason, AT&T's predictions for Picturephone and what actually happened were almost at opposite ends of the spectrum of reality. In short, Picturephone failed. By 1976, there were

only 400 Picturephones in use in Chicago and several more in AT&T corporate offices, and plans to market the service on a nationwide basis had long since been abandoned.²⁸ There are probably many reasons for the demise of Picturephone. Poor resolution, small picture image, and substandard graphic transmission were certainly factors.²⁹ Consider also the Bell System's marketing approach, and the fact that test marketing was done with the working public, not the businessman, AT&T's initial market target. The Bell System network also proved to be a problem. From the outset, switching was troublesome, and as already mentioned, special video switches were required within central offices to handle Picturephone signals. Maintenance also appeared to be a potential AT&T headache. Finally, it was obvious that wide acceptance of Picturephone would require major expansion of the Bell System wire plant. Realizing this, AT&T may simply have had second thoughts regarding the advantages of widespread Picturephone use.

Cost was also a factor in the downfall of Picturephone. The cost of this tremendous new video telephone which would so vastly alter our lives was high, but considering the time and money which must have gone into its development it was probably not unreasonable. Although no official figures are available, one authority estimated that AT&T invested a total of \$500 million to develop the Picturephone.³⁰ In return, the Bell System announced its intentions to charge a varying number of rates for Picturephone service, depending upon who asked, when they asked, and the location in question. Initial predictions placed the cost of Picturephone at \$100 per month in the Pittsburgh area plus local message unit rates three

times those of existing telephone rates and long distance charges ten times those for audio telephone service.³¹ One year later the monthly lease rate has been revised upward to \$130-140, but this rate included 30 minutes of free video time for local calling.³² Four months later the monthly charge was at \$160.³³ Although specifics on installation charges were not available, there is evidence that they were also extremely high, and they alone were enough to discourage potential customers.³⁴ When service was finally initiated in Pittsburgh, the actual charge was \$150 per month, including 30 minutes of free video time for local calling, plus unit message charges; rates put in effect later for service in the Chicago area were set at about half this amount.³⁵

Video Teleconferencing: 1969-1973

The enthusiasm and confidence which the Bell System displayed over Picturephone in the late 1960's and the great technical progress which they made towards making video teleconferencing a telecommunications reality, sparked a worldwide video teleconference movement, beginning in about 1969, as others began working on their own systems, hoping to capture a share of this potentially lucrative market. The video teleconference systems to emerge during this period were video telephone systems, most of which were spin-offs of the Picturephone. The high cost and limited applications of these animated systems later prompted the development of slow scan units and telefacsimile systems.

Other Video Telephones

With the benefit of Bell Telephone's extensive publication of

details about Picturephone in the open literature, several other telephone companies and countries developed animated video telephone systems of their own. In the United States, Stromberg-Carlson, a subsidiary of General Dynamics, developed the Vistaphone.³⁶ Externally, the Vistaphone closely resembled the Picturephone, but the electronics were very different. Picturephone contained many components which were specifically developed at Bell Laboratories, such as the silicon diode camera tube and numerous integrated circuits, while Vistaphone was constructed entirely from components available off-the-shelf.³⁷ Vistaphone was the only fully animated video telephone, besides the Picturephone, to enter into actual production in the United States.³⁸ General Telephone and Electronics also made a video telephone, the Pictel.³⁹ The Pictel did not look like Picturephone and Vistaphone, however, it offered the same basic features. It was demonstrated to the public in 1971, but was never actively marketed.

Outside the United States, video telephone development was also active. The one most thoroughly publicized was produced by the L.M. Ericsson Company of Stockholm, Sweden, an international telecommunications equipment manufacturer. The Ericsson device was the one used on both ends of the first transatlantic video telephone demonstration in December 1971.⁴⁰ Ericsson believed that video telephones would be used first to promote business office efficiency, thus their system design stressed the importance of high resolution for transmitting texts and graphics. However, the overall Ericsson system employed a hierarchy of three transmission qualities:

- (1) Broadcast television standards were employed

for private intercom systems, and short transmission paths.

- (2) The signal was reduced from 4 MHz to 1 MHz for service outside a local area where conditioned telephone pairs were available.
- (3) Where conditioned telephone pairs were not available, a high resolution, 4 kHz signal was sent.⁴¹

As of 1973, the Ericsson video telephone had not yet entered into production. It is highly probable that it never did.

In the United Kingdom, the British Post Office experimented with a video telephone device which they called the Viewphone; however, these trials were limited, and the British Post Office efforts have since turned to Confravision, a studio-based system which will be discussed later in this chapter. Also in the United Kingdom, Automatic Telephone and Electric demonstrated a video telephone with 228 lines, 25 frames/sec, 50 fields/sec, and a 555 kHz bandwidth.⁴² Resolution on this system was said to be extremely poor. Pye, Ltd., an electronics and electrical instruments manufacturer in Cambridge, England, took Videophone⁴³ as a registered trademark in the early 1970's but the Videophone never materialized.⁴⁴

In Japan, Nippon Electric, Fujitsu, Hitachi, and Toshiba all developed video telephones. All Japanese systems were developed primarily with text and graphic transmission in mind, and used a 4 MHz bandwidth for high resolution.⁴⁵ Three French companies, CIT-Alcatel, Thomson-Brandt, and Matra worked on a system called Visio-phone; however, literature indicates that this system was never placed into full-scale production.

Preliminary Assessment

The paragraphs above have briefly described eleven animated video telephones (including Picturephone). These systems were developed in at least five countries, and tested between 1969 and 1973. To the best of our knowledge, not one of these systems is used extensively today. Many factors contributed to the rise and fall of the animated video telephone; cost, design, bandwidth limitations, and human factors, to name a few. It is the opinion of the authors, based upon an extensive review of the literature on video teleconferencing, that Picturephone-type instruments will not enjoy widespread use and acceptance for many years to come, and perhaps never. Many of the uses which video telephone developers envisioned for the home have been or will be satisfied through other technologies. Business needs will be better satisfied by studio-based systems. The experience and technical progress which came from the video telephone phase of video teleconference development were beneficial. However, that work which was aimed specifically at video telephone development will most likely be lost forever.

Slow Scan Video Telephones

Some companies did not rush to produce an animated video telephone system when Picturephone was introduced. Instead, they placed their faith in a slow scan system. The decision to produce a slow scan system rather than an animated one was based on three assumptions:

- (1) Business concerns, not individuals, would be the first to adopt video telephones.

- (2) Business concerns were more interested in a high resolution system which could transmit good quality text and graphics than seeing the person to whom they were talking, face-to-face.
- (3) The high cost of animated video telephones would be a major deterrent to their adoption by business in the foreseeable future.⁴⁷

In retrospect, these assumptions proved to be correct, at least in the short term.

Perhaps the most widely publicized slow scan video telephone to be developed was the Videovoice⁴⁸ which was manufactured and sold by RCA Global Communications. The Videovoice system could transmit a "frozen" picture in about 30 seconds.⁴⁹ During the graphic transmission period the audio conversation was interrupted, but this interruption was brief. The purchase price of the system was about \$10,000, or about \$200 per month with a minimum contract lease of six months.⁵⁰ RCA launched its marketing campaign in 1971 with great expectations, "hoping to fatten its better than 50% share of the international communications business with Videovoice."⁵¹ The effort was dropped at the end of 1974, however, at which time less than 200 units had been sold.⁵²

At about the same time that RCA was producing Videovoice, Colorado Video, Inc., a small company in Boulder, Colorado, developed a completely different slow scan system. This system is still being sold today. A standard commercial grade camera and receiver (normally used for CCTV), and two other units developed and manufactured by Colorado Video; a transmitter and receiver scan-converter, and a magnetic disk memory to record and store the video signal, comprise the Colorado Video System.⁵³ The slow scan signal can be transmitted

over normal voice grade lines. Like Videovoice, the Colorado Video system does not permit simultaneous audio and video transmission, unless two separate telephone wire pairs are used.

Telefacsimile

Many of the same reasons which prompted the birth of slow scan video telephones were also responsible for the emergence of voice-telefacsimile teleconference systems. Two of the most prominent such systems were established by U.S. Government agencies, the General Services Administration (GSA) and the National Aeronautics and Space Administration (NASA). Both systems were studio-based and were implemented primarily to save travel costs. Both systems are still in use today.

The NASA Teleconference System was first established during the Apollo moon landing program to facilitate technical and policy exchanges between widely scattered manufacturing, test, and management centers. The system, which interconnected eleven different locations, each of which had a teleconference room which could seat up to 50 persons, was capable of both low speed (up to four minutes a page) and high speed (about 40 seconds a page) facsimile transmission.⁵⁴ The cost of the entire system, including equipment, lines, conference rooms, and system operators was estimated to be \$486,000.⁵⁵ In 1974, the system was expanded and modified to serve the needs of the Space Shuttle program.

The GSA Teleconference System was placed in operation in 1975. The system interconnects eleven specially designed conference centers in Atlanta, Boston, Chicago, Dallas, Denver, Kansas City, New York, Philadelphia, San Francisco, Seattle, and Washington, D.C.⁵⁶ Each

conference center can accomodate up to 25 conferees and all eleven centers can be connected simultaneously.⁵⁷ The GSA system is available to all federal agencies on a cost-reimbursable basis. The cost involved depends upon the length of the conference, the locations connected, and the number of connections required.⁵⁸ GSA originally planned to incorporate digital facsimile, video, and on-line graphics into this system, but as yet, no such modifications have been made.

Video Teleconferencing: 1973 to Present

As stated earlier most of the video telephone systems described above had failed by 1973. Manufacturers of those which were still in existence knew that it was just a matter of time. Consumers considered the video telephone an expensive luxury and telecommunication manufacturers and businessmen questioned its usefulness. At the same time, slow scan and telefacsimile teleconference systems could only partially satisfy the needs of these user groups. For a while, it appeared that this period in the evolution of video teleconferencing had severely crippled the chances for more sophisticated systems to come into being. Then came the Middle East Oil Embargo of 1973 and 1974. Fossil fuels became scarce and eventually much more expensive. As a result, transportation costs soared, and businesses and government began looking for ways to cut their travel costs without damaging their operation. The potential ability of video teleconferencing to do this was brought to the surface, and a new era in the development of video teleconference systems began.

CCTV Video Teleconference Systems

Closed Circuit Television (CCTV) systems have gained the most prominence during this period of video teleconference development. The following paragraphs summarize the most publicized CCTV video teleconference systems which have been placed into operation to this date. Great Britain's Confravision and Australia's Sound-in-Vision are described first, followed by a description of several domestic systems.

Great Britain's Confravision: The British Post Office first introduced Confravision in 1973, in a limited form. Today, Confravision studios are located in the cities of Glasgow, Manchester, Birmingham, Bristol, and London, England, as well as Stockholm and Malmo, Sweden and the Hague and Amsterdam in the Netherlands. Both two- and three-way conferencing is available within Great Britain, via microwave and coaxial cable, but the service is limited to two-way only when communicating with locations in Sweden and the Netherlands.

Each conference studio is air conditioned, sound proofed, and customer operated; however, a Post Office attendant is positioned in the next room to provide assistance should it be required. Five conferees can be seated at the conference table, and four more can be seated in a row directly behind the first five. A monochrome conference camera can be focused on the central three conferees in the front row, or all five conferees at the touch of a button. A display camera, located on the left side of the main conference area, allows the transmission of black and white documents, graphs, charts, and small objects.

The video signal is displayed on two standard black and white

television screens, mounted side by side, directly in front of the conferees. Another television receiver, situated on the right side of the conference area, monitors the outgoing signal. An audio tape recorder can be used to record the audio portion of the conference or to transmit pre-recorded messages.⁵⁹

Australia's Sound-in-Vision: Australia's Sound-in-Vision, like Confravision, is a studio-based, off-premise system which is controlled by the government's telecommunication agency. First tested in 1974, the system links conference studios in Sydney and Melbourne, Australia. Each studio is air conditioned, sound proofed, and can accomodate up to six conferees. Sound-in-Vision was designed to allow complete user operation. All cameras, monitors, and audio components are available, commercially, off-the-shelf.

The unique feature of Sound-in-Vision lies in the video techniques employed, and in a specially designed device called a video switching unit (VSU).⁶⁰ The VSU allows the use of a video transmission technique known as synchronous half-field injection. This technique divides the total video display into two half-height (half-field) displays. In doing so, it takes advantage of the fact that the standard television picture ineffectively displays irrelevant material in the background and foreground.

Figure 1-A illustrates the equipment and studio layout required to achieve synchronous half-field injection. Figure 1-B illustrates the function of the VSU in this operation. In simple terms, the video signal from camera A, which contains the images of the three conferees on the right hand side of the conference table, is compressed into the upper half-field of view while the signal from

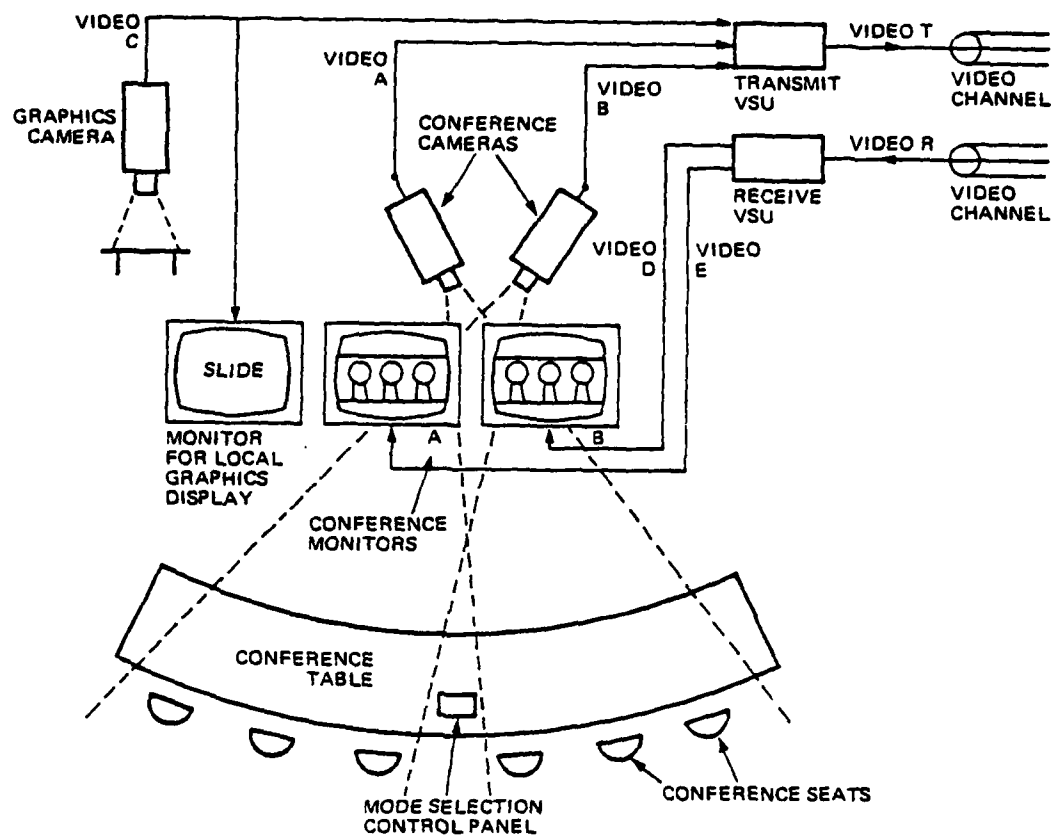


Figure 1A. Conference Facility Layout: Australia's Sound-in-Vision.

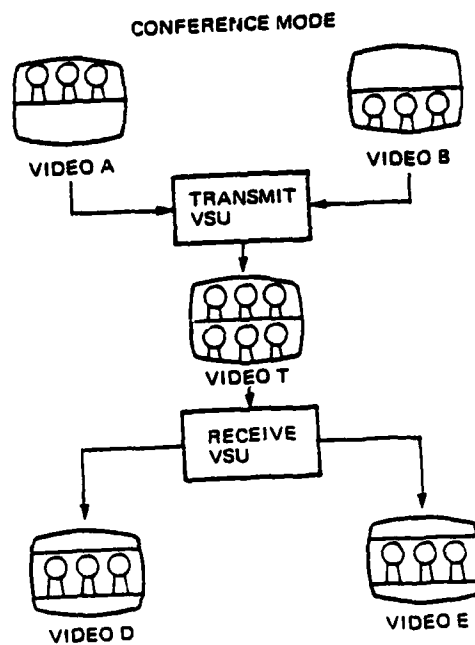


Figure 1B. VSU Operation.

GRAPHICS MODE

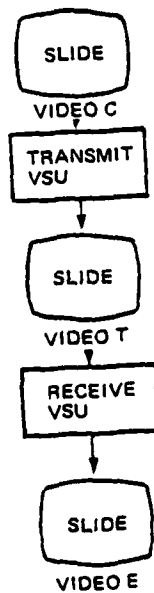


Figure 1C. Graphics Mode
Australia's Sound-In-Vision

camera B, which contains the images of the three conferees on the left, is compressed into the lower half-field. Compression is possible because the meaningless information contained in the background (above the conferee's heads) and the foreground of the picture (below the conference table) are eliminated. The compressed video signal from both cameras is then time division multiplexed by the VSU to produce a single video signal whose content is a stacked arrangement of the two groups of three conferees. The signal is transmitted in this form. At the other end, the receive VSU separates the signal into its two half-field components for display on two receive conference monitors. The video information which was contained in each of the compressed half-fields is displayed in the center of a conference monitor with the top (where background would normally be) and bottom (where foreground information would normally be) blanked out.

In addition to the conference mode just described, Sound-in-Vision offers a graphics mode, for presenting documents, 35 mm slides, and transparencies (Figure 1-C). In this mode, synchronous half-field injection is not employed. A special graphics console is provided to accommodate the graphics mode.⁶¹

The Australian Post Office has studied the feasibility of multi-location conferencing with Sound-in-Vision. Geographically, Australia is especially well-suited for such an arrangement since the population is concentrated predominantly along a coastal strip. Thus, all terminals could be engineered as points along a single broadband transmission chain.⁶²

Dow Chemical USA Interactive Television System: The first privately-owned, studio-based, CCTV teleconferencing system in the United States was placed into operation by Dow Chemical, USA in 1973. The system connects Dow Chemical headquarters in Midland, Michigan with its manufacturing division in Freeport, Texas (a distance of about 1400 airline miles). It is used to conduct technical conferences, laboratory experiments, product business team meetings, and management planning discussions.⁶³

The system uses network television circuits and mobile color television equipment. Transmission is made over AT&T microwave links. The video portion of the signal is displayed on a 6-foot by 8-foot rear projection viewing screen. System cost is high. The cost of the television equipment and studios was \$300,000 (in 1975); the hourly rate for the 1400-mile transmission link was about \$2,000.⁶⁴ Despite high costs, Dow Chemical's President, Earle B. Barnes, considers the benefit/cost ratio of the system to be very favorable.⁶⁵

New York-Boston Banking Video Teleconferencing System: This system was installed in mid-1970 between The First National City Bank of New York, The First National Bank of Boston, and The Banker's Trust of New York. The purpose of the system was to facilitate quick investment decision-making in response to rapid fluctuations in stock market quotations. The system offered the capability to transmit both in the conference and text and graphics modes. Transmission was via coaxial cables leased from AT&T, reportedly at considerable expense. For instance, The Banker's Trust of New York paid \$11,000 in 1974 for a three and one-half mile link between its teleconference rooms.⁶⁶ The total system was used less than two

hours a day. It has since been discontinued.⁶⁷

The Metropolitan Regional Council Television System, MRC-TV:

MRC-TV is a two-way, audio-visual teleconference system which is operated by the Metropolitan Regional Council, which serves participating government centers in the New York, New Jersey, and Connecticut Metropolitan areas. The network links eleven conference studios located in these areas so that local governments can exchange ideas and information without having to travel. An MRC-TV Guide is published in advance each month to let subscribers know what items have been scheduled for discussion. Examples are as follows: police stress and problems; asbestos, cancer and our children; welfare reform; consumer protection; HUD; clerical and secretarial development; the critical state of public mass transit; and affirmative action/equal employment.^{68,69} A detailed explanation of the scope of discussion for each of these topics is also provided in the TV Guide.

The system uses over-the-air transmission. A central control facility is located in the World Trade Center (WTC) in New York City. All signals are hubbed in and out of this facility. One main low-power transmitter broadcasts omnidirectionally to the eleven studio locations using two pylon antennas which are mounted on top of the WTC. Since the WTC transmitter operates at low power, the receiving sites use 10 foot parabolic dish antennas. A separate antenna is used for transmission. All transmission and reception from the outlying sites to the WTC is via line-of-sight paths.⁷⁰

Studios are equipped with remote control cameras and CCTV monitors. The total investment cost for the MRC-TV system (including

antennas, CCTV equipment, studios, etc.) was approximately \$75,000, 75% of which is covered by a ten year lease. Annual operating costs in 1974 were estimated at \$275,000.⁷¹

Communications Technology Satellite Experimental Systems: Since 1977, the United States-Canadian Communications Technology Satellite (CTS) has been used to test the feasibility of video teleconferencing using high power and high frequency transmission and small earth station antennas (see Chapter II). Portable earth stations have been transported for tests at more than 50 locations in the United States,⁷² during which time much valuable information has been gathered. Three of these tests, conducted at Westinghouse USA, the U.S. Congress and the National Oceanographic and Atmospheric Administration (NOAA), will be discussed here.

-- Westinghouse Electric Corporation CTS Teleconference System. The Westinghouse experiment is being conducted between its Baltimore, Maryland facility and its Aerospace Electrical Division at Lima, Ohio, a distance of about 450 miles. The system provides two-way audio and color video service between studios at these locations. As with all CTS test systems, the user must provide its own studios and video and audio equipment. The Westinghouse studios can accommodate three conferees, with a voice activated camera dedicated to each. Although these cameras are focused primarily on a single conferee, all conferees remain in the camera's field of view. When a conference participant speaks, his camera is automatically connected to the outgoing video channel. To the viewer, only the camera angle changes. A fourth camera is used for text and graphics. The incoming video signal is projected on a screen which is 52 inches by 69 inches;

smaller sets are also present to monitor the outgoing transmission.⁷³ Electronically, the Westinghouse tests have been very successful. In fact, absolutely no significant problems have been reported with the video portion of the tests. Squelch, delay, and echo suppression difficulties were encountered with the audio portion; however, and as we shall see, these difficulties are, as yet, not fully resolved.

-- U.S. Congress CTS Video Teleconference Test. On June 8, 1977, the Senate Subcommittee on Science, Technology, and Space conducted a three and one-half hour legislative hearing with a panel of scientists located over 800 miles away in Springfield, Illinois. The hearing was conducted via a CTS video teleconference system. This demonstration, and two others like it, was arranged by Fred B. Wood of George Washington University. Aside from occasional audio problems, similar to those noted in the Westinghouse test, the Congressional tests went very well. Senators who participated included Adlai E. Stevenson, Illinois; Barry Goldwater, Arizona; Howard Metzenbaum, Ohio; Lee Metcalf, Montana; James Pearson, Kansas; and Harrison Schmitt, New Mexico. Based upon the favorable reactions of these men, an unofficial bipartisan group of 75 members of the House of Representatives has asked Western Union and RCA to submit proposals for bargain rates on satellite channel time, during non-peak hours, to be used for a permanent Congressional video teleconference system, sometime in the future.^{74,75}

-- NOAA Satellite Communication System. The first NOAA test using the CTS satellite was conducted on July 21, 1977, when representatives from NOAA's Equal Employment Opportunity (EEO) committee in Rockville, Maryland and Seattle, Washington met in the video conference

mode to discuss NOAA's EEO program. Since that time, NOAA has used the CTS system extensively to test video teleconferencing between both two and three locations, simultaneously.⁷⁶ On June 15, 1979, we witnessed a test between NOAA's Global System Forecast Center in Boulder, Colorado and the Environmental Research Laboratory in Greenbelt, Maryland. NOAA's CTS test system will be discussed from the standpoint of observations made during, and personal interviews conducted immediately following this test.

Figure 2 depicts the conference room layout at the Boulder facility. The room was arranged to accommodate up to four conferees. In addition, seating is available for up to 70 additional people in the audience. The equipment used was almost entirely manufactured by Sony. Two CCTV television cameras were situated on either side of the room, about half way into the audience. The camera on the right was directed at the two individuals seated on the left-hand side of the conference table, while the camera on the left was directed on the two individuals seated on the right-hand side. Camera operators were used, and a zoom lens allowed the operator to capture the image of just the person speaking, or a wider view of both persons seated on his side of the facility. All conferees wore lapel microphones.

The incoming video signal was projected on a variety of screens so that all conference participants and all members of the audience were able to see. A 25 inch CCTV was situated about 5 feet from the conference table for the conferees. The audience viewed the incoming signal on two other 25 inch CCTV's, which were elevated approximately 5 feet in the air, and were located about 6 feet from the front row

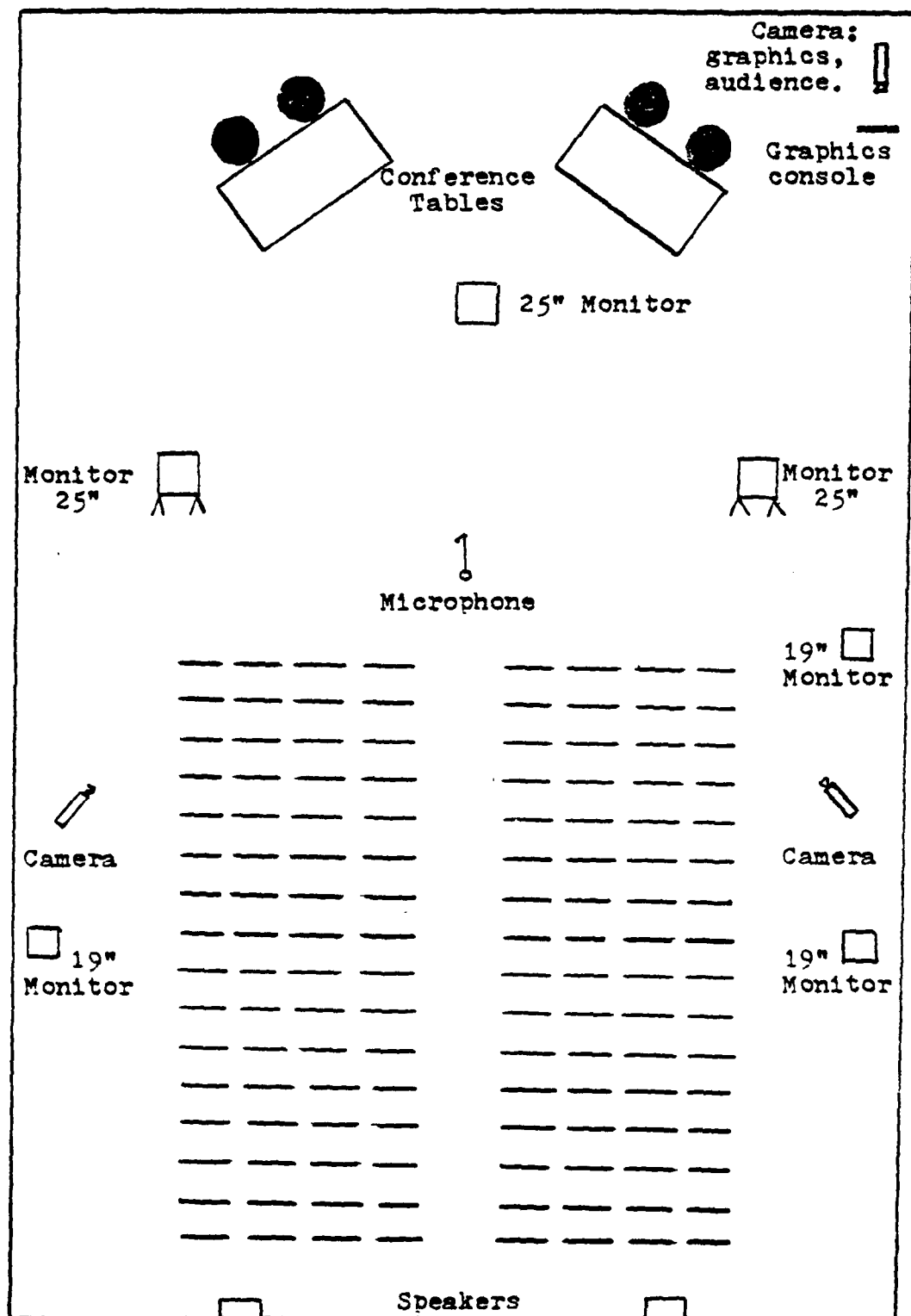


Figure 2. NOAA CTS Test System (Conference Facility).

the audience. For those seated near the rear, two 19 inch television sets were wall-mounted, along the side of the room. Another 19 inch set was wall-mounted on the right-center of the room, about half-way back, to monitor the outgoing signal. Incoming audio was projected through two 36 inch speakers, located in the rear of the room.

A separate camera, located to the right and behind the conference table, was used for graphics and for audience participation. If a conference participant wished to use a graphic to illustrate a point, the camera was zoomed in on the graphic. If a member of the audience wished to contribute to the conference, the camera could be rotated and focused on him. Audience participation was from the pedestal-mounted microphone located in the middle of the room near the front row of the audience. Control of which of the three conference cameras was "on-the-air" was executed from a video control panel located across the hall from the conference facility.

AT&T's Picturephone Meeting Service: One final CCTV video teleconference system will be discussed, AT&T's Picturephone Meeting Service (PMS). Unlike its name might imply, Picturephone Meeting Service does not utilize the AT&T Picturephone developed in the late 1960's, which was discussed in a previous section of this chapter. Another interesting fact is that there has been almost no information published by AT&T about this new service, despite the fact that it seems to be much more in tune with today's video teleconference requirements than the Picturephone was in the late 1960's (recall that AT&T publicized widely on Picturephone). As evidence, not one article written specifically on PMS was published in the Bell Laboratory

Record or the Bell System Technical Journal from 1975 to 1980.^{77,78}

Picturephone Meeting Service is currently available in six cities: Chicago, Los Angeles, San Francisco, New York, Washington, D.C., and Atlanta. Users must arrange for the service in advance by calling their local AT&T PMS representative and reserving the PMS conference room located in their city. These conference rooms are set up to look very much like the average corporate conference room and are designed to accommodate up to six active participants.⁷⁹

Each conference center is equipped with six video cameras. Three of these cameras, each of which covers two of the conferees, are voice activated. Another camera, mounted overhead, photographs all six conferees at once, while a fifth camera handles large graphs and charts. The sixth camera is mounted on a platform and is pre-focused for small charts and graphs. Two black and white television monitors allow conference participants to watch the outgoing and incoming signals, simultaneously. Full-motion color has been tested between Los Angeles and New York, but resolution is still not good enough for graphs and documents.⁸⁰

A 4 MHz bandwidth is required to transmit the PMS voice and video signal. The video signal, which is digitally encoded for transmission, is of the same quality as commercial black and white television.⁸¹ Despite the high bandwidth and video signal quality, the cost of PMS is very competitive. For instance, the charge for a one hour conference between New York and Los Angeles is \$390.50, which is less expensive than a round-trip airline ticket.⁸² This charge is all-inclusive, with the exception that users who wish to videotape their conference must furnish their own tapes.

Other CCTV Video Teleconference Systems

The eight CCTV video teleconference systems discussed thus far certainly do not exhaust the list of such systems which have been placed into operation over the years. For instance, many CCTV systems have been developed in the medical community to support activities such as remote treatment facilities, and information exchange programs. Included in this category are the Vermont-New Hampshire Medical Interactive Television Network, the Massachusetts General Hospital-Veteran's Administration Hospital CCTV Network, and the Arizona Telemedicine Network.⁸³ Also included are systems as the Louisiana Hospital TV Network, the Georgia Regional Medical TV Network, the Nebraska Psychiatric Institute and the Alaska Medical TV System.⁸⁴ CCTV video teleconference systems have also been used in the area of education to conduct remote education programs. In some cases, video teleconferencing is used to allow students in outlying areas to receive lectures and course instructions from professors located on campus, without the need for either of them to travel. In other cases, students located on campus were able to see, hear, and interact with visiting lecturers, with no travel involved. Examples of these systems include those at Hagerstown, Maryland, Indiana University, the University of Florida, and the United States Military Academy at West Point.⁸⁵ Medical and education systems will be discussed further in Chapter VI when the social benefits of video teleconference systems are considered.

Video Teleconference Systems Today

This chapter has been devoted, primarily, to discussing the

characteristics and functions of video teleconference systems as they have developed over the years. In doing so, we have compiled the most comprehensive list of video teleconference systems known to us. It will be useful at this time to stop and consider which of these systems have survived, i.e., which video teleconference systems are in use today.

Table II lists the present day systems and their predominant characteristics. A comprehensive review of this list will yield the following common characteristics and trends in present day systems. Current video teleconference systems are generally:

- (1) Privately-owned.
- (2) Animated.
- (3) Studio-based.
- (4) Large screen -- and the trend is toward even larger screens.
- (5) Multi-mode, i.e., conference mode and text and graphics mode.
- (6) User operated.
- (7) CCTV.
- (8) Black and white -- but the trend is toward full color.
- (9) Point to point, two-way only, but the trend is toward simultaneous multi-location conferencing.
- (10) Transmitted over a variety of broadband links, but the trend is toward satellite and fiber optics.
- (11) Located on-premise.

What About Telefacsimile?

Two telefacsimile systems are included in the list of active

TABLE II
VIDEO TELECONFERENCE SYSTEMS IN USE TODAY

System	Location	Black & White/ Color	Private Government Commercial	No. of Simultaneous Conferences	Media	Transmission Link
Picturephone Meeting Service	Studio, Off-premise	BW	Private	2	CCTV	Bell Network
Confravision/ Great Britain	Studio, Off-premise	BW	Government	2 or 3	CCTV	Microwave and Coax
Sound-In-Vision/ Australia	Studio, Off-premise	BW	Government	2	CCTV	?
MRC/TV	Studio, On-premise	BW	Local Government	11	CCTV	Broadcast
CTS* Experimental	Studio, On-premise	Color	Private and Government	3	CCTV	Satellite
Vermont-New Hampshire	Studio, On-premise	BW	Private	2	CCTV	Microwave
Massachusetts General Hospital Net	Studio, On-premise	BW	Private	2	CCTV	Microwave

TABLE II (Continued)

System	Location	Black & White/Color	Private Government Commercial	No. of Simultaneous Conferences	Media	Transmission Link
Arizona Tele-Medicine	Studio, On-premise	BW	Private	2	CCTV	Microwave
Louisiana Hosp Net	Studio, On-premise	BW	Private	2	CCTV	Microwave
Georgia Regional Med Net	Studio, On-premise	BW	Private	2	CCTV	?
Nebraska Psychiatric Inst Net	Studio, On-premise	BW	Private	2	CCTV	?
Alaska Med TV Net	Studio, On-premise	BW	Private	2	CCTV	Satellite
Hogerstorm, MD. Education System	Studio, On-premise	BW	Private	2	CCTV	Microwave
Indiana University	Studio, On-premise	BW	Private	2	CCTV	?
University of Florida	Studio, On-premise	BW	Private	2	CCTV	?

TABLE II (Continued)

System	Location	Black & White/ Color	Private Government Commercial	No. of Simultaneous Conferences	Media	Transmission Link
United States Military Academy	Studio, On-premise	BW	Government	2	CCTV	Microwave
Dow Chemical USA	Studio, On-premise	BW	Private	2	CCTV	Microwave
NASA Space Shuttle System	Studio, On-premise	BW	Government	11	Telefax	Telephone
GSA Teleconfer- ence System	Studio, On-premise	BW	Government	11	Telefax	Telephone
Conference Television/ Canada	Studio, Off-premise	BW	Commercial	?	CCTV	?
Massachusetts Gen Hosp-Logan Airport	Studio, On-premise	BW	Private	2	CCTV	Microwave
Mt. Sinai Hospital	Studio, On-premise	BW	Private	2	CCTV	?

TABLE II (Continued)

System	Location	Black & White/Color	Private Government Commercial	No. of Simultaneous Conferences	Media	Transmission Link
Univ. of Alabama School of Dentistry	Studio, On-premise	BW	Private	2	CCTV	?
NYC Health Services Administration	Studio, On-premise	BW	Private	2	CCTV	?
Los Angeles Medical TV Net	Studio, On-premise	BW	Private	2	CCTV	Microwave
Network for Continuing Medical Education, N.W.	Studio, On-premise	BW	Private	2	CCTV	Microwave
MEDINAV-U.S. Navy	Studio, On-premise	BW	Government	2	CCTV	Microwave

* Includes numerous tests using the joint USA/Canadian CTS Satellite. CTS is scheduled to reach the end of its useful life in about three months.

video teleconference systems above. Although only two are included, it is probable that many more are in existence. Yet, telefacsimile is not included in the preceeding list of current day trends and characteristics.

There are two reasons for this exclusion. First, the potential benefits to be derived from telefacsimile-only type systems, in terms of energy and travel savings, medical and educational advances, aid to the deaf, etc., are simply not as great as with other video teleconference systems. Second, the primary role that we see for telefacsimile in the near future, from the standpoint of present-day video teleconference systems, is one of augmentation. Resolution on an animated video teleconference system may be adequate for transmitting the images of people, however, it is often inadequate for transmitting text and graphics. In these cases, telefacsimile can be used for the text and graphics mode.

Telefacsimile played an important role in the evolution and development of video teleconferencing described in this chapter. Today, however, it should be evaluated separately, on its own grounds. It is for these reasons that telefacsimile-only systems will not be included in the discussions in the remainder of this paper.

The Scope of the Remainder of this Paper

We believe that video teleconference systems have reached a stage of temporary maturity, and that they will not undergo any revolutionary changes within the next three to five years. Thus, the characteristics and trends listed above will continue to dominate during this time period. The remainder of this paper, then, will concentrate on the video teleconference system of today.

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CHAPTER III

RELEVANT AND COMPETING TECHNOLOGIES

Video teleconferencing, as indicated in Chapter II, had developed over a period of many years. This same period has also seen the development of many other extremely useful and diverse technologies representing a wide spectrum of electronic techniques and equipment. Several of these technologies have the potential for directly affecting the capability, utility, and acceptability of video teleconference systems. Some of these technologies can result in reducing the cost of operating video teleconference systems while others will increase the effectiveness of these systems. A third category of technologies is often regarded as competition for video teleconferencing and a fourth category may well be complementary if they are properly combined with video teleconference systems.

The primary means of communication used in the world today, other than face-to-face discussion, is the telephone. A vast network of equipment including the telephone instruments, interconnecting lines, and switching facilities has been developed and installed over the years to support the ever increasing demand for telephone service. Naturally this network was designed to meet the requirements of this "audio" form of communication and since it has been found that most of the energy and information in human speech is in the tones below 3000 Hz, the telephone network has been built around what is commonly referred to as 3 kHz voice channels. However, just as one perceives more

information by observing and speaking with a person face-to-face than one does by only hearing that person's voice, a "video" system transmits more information than an "audio-only" system. One of the electronic consequences of this fact is that the 3 kHz voice channel used by the telephone does not have adequate capacity for use with a video teleconference system. The capacity of a transmission channel is normally referred to in terms of bandwidth and a channel adequate for transmitting a standard video signal must have approximately 1500 times the bandwidth capacity of a standard voice channel.¹ In the United States, television channels are allocated 6 MHz of bandwidth which accommodates both the audio and video portion of the standard broadcast television signal.²

The cost of providing a wide bandwidth video channel over any appreciable distance is quite significant and this has been one of the major deterrents to the widespread acceptance of video teleconference systems. Two approaches have been followed in attempting to resolve the problem of providing an economical video transmission system. One approach is to develop cost effective wide bandwidth transmission systems (see Figure 3) and the other is to reduce the bandwidth of the video signal through redundancy reduction techniques. The three sections following will discuss examples of these approaches.

Satellites

Satellite communications has been perhaps the most rapidly evolving communications transmission system since its beginnings in the mid 1960's. In 1962, Congress authorized the formation of the Communications Satellite Corporation (Comsat) as a private company

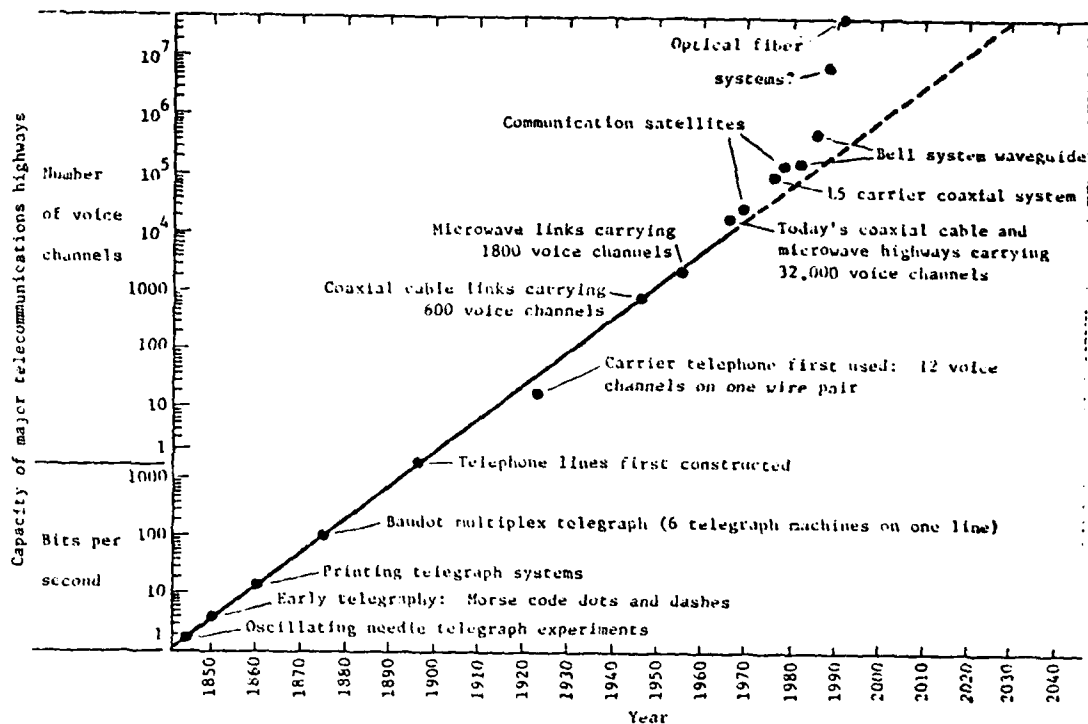


Figure 3. Growth in Telecommunications. (Source: National Transportation Policy Study Commission, The Impact of Telecommunications on Transportation Demand Through the Year 2000.)

chartered to establish a global commercial satellite communications network in cooperation with other countries and in 1964 the International Telecommunications Satellite Organization (INTELSAT) was formed.³ INTELSAT, which had grown to 102 member countries by 1978,⁴ launched Early Bird (INTELSAT I), the world's first commercial communications satellite, on April 6, 1965.⁵ The next six years saw the launch of four generations of INTELSAT series communications satellites and the fifth generation (INTELSAT IV-A) is now in operation. In the 1970's, various domestic and regional satellite communications systems were developed, with the United States' first domestic entry being the WESTAR I which was launched by Western Union Telegraph company in 1974.⁶ Many other satellite systems have been planned and developed and Table III provides a listing of many of the satellite systems, including earth stations, in use or in the planning stages throughout the world.

The basic reason for the rapid expansion in satellite use is their ability to provide improved quality, high capacity, point-to-multipoint transmission over long distances at a cost which is insensitive to the distance involved. An example of the capacity of communications satellites is the Early Bird (with only 50 MHz bandwidth) which increased the transatlantic telephone capacity by more than one third.⁷ One of the current series, INTELSAT IV-A, which operates in the 4/6 GHz band, has a total of 20 transponders each with a 36 MHz bandwidth.⁸ The INTELSAT V (due to be launched in the near future) will operate in both the 4/6 GHz and the 11/14 GHz bands and will have a total available bandwidth of 2290 MHz on each satellite.⁹ While not all of a satellite's bandwidth can be

TABLE III
COMMUNICATIONS SATELLITE SYSTEMS

International Satellite Systems

Intelsat Satellite Systems
Intersputnik Satellite System

Regional Satellite Systems

African Satellite System
Andean Satellite System
Arab Satellite System
European Communications Satellite System
Nordic Countries Satellite System

Military Satellite Systems

Air Force Satellite Communications System
Defense Satellite Communications System
Fleet Satellite Communications System
NATO Communications Satellite Project
U.K. Skynet Defense Communications Network
U.S.S.R. Cosmos Military Satellite Network

Special Purpose Satellite Systems

Aeronautical Satellite System
European Broadcast Union Television Satellite System
Maritime Satellite System
Maritime Orbital Test Satellite
Tracking and Data Relay Satellite System
Volna Satellite System

Experimental Satellite Systems

Applications Technology Satellite
Communications Technology Satellite
German Direct Broadcast Satellite
Japanese Experimental Communications Satellite
Lincoln Experimental Satellite System
Orbital Test Satellite
Phebus
Sirio
Symphonie
Syncom IV
Tacsatcom

Domestic Satellite Systems

Algeria	Mauritania
Australia	Nigeria
Brazil	Norway
Canada	Oman
Chile	Peru
China	Philippines

TABLE III (continued)

Coloumbia	Saudi Arabia
France	Spain
India	Sudan
Indonesia	Thailand
Iran	Uganda
Japan	United Kingdom
Libya	United States
Malaysia	U.S.S.R.

(Source: Satellite Communications, "The Global Communications
Satellite Catalogue".)

utilized due to satellite power limitations, efficiency and size of earth station antennas, and attenuation effects of the earth's atmosphere for those earth stations not directly under the satellite, the average load capacity of an INTELSAT IV-A is 6000 voice circuits plus two television channels. By reducing the number of voice channels in use on the satellite, the number of available video channels can be increased up to a total of twenty.¹⁰

Other satellite systems such as the experimental CTS satellite, jointly launched by NASA and the Canadian Department of Communications, are being tested using higher satellite transmitter power and wider bandwidth transponders (85 MHz) and indications are that these types of satellite systems will provide even greater communications capacity than those systems in use today. One entry in this category is being planned by Satellite Business Systems (SBS), a consortium of Comsat General, International Business Machines, and Aetna Life and Casualty. This system will operate in the 11/14 GHz band and will provide communications links to a large number of customers who will own and operate earth stations colocated with their own business locations. The utility of this system for video teleconferencing has been demonstrated by actual video business conferences conducted by Montgomery Ward, Rockwell International, Texaco, and Aetna Life and Casualty. SBS hopes to use this system to compete with American Telephone and Telegraph's Picturephone Meeting Service.¹¹

Obviously satellites have the utility to provide wide bandwidth and high capacity communications links. They also have an additional advantage in that transmission cost is independent of distance. Furthermore, the cost per voice circuit per year for satellite systems has been declining rapidly while the capacity and projected useful

life of the satellites have shown marked increases. The cost per voice circuit per year of the Early Bird was \$23,000 while the same figure for INTELSAT V is projected to be approximately \$200.¹² The cost of earth stations per circuit have fallen just as rapidly as that of the satellites and promise to drop even further with the increased use of the 11/14 GHz band since antenna size will be smaller.

As with other communications links, satellites also have some disadvantages and problems. Among these are limitations on frequency resources, limitations on geosynchronous orbit slots, and transmission delay effects on satellite communications.

The altitude of a satellite in a geosynchronous orbit above the equator is approximately 22,300 miles and the time required for a signal to travel from a ground station to the satellite and back down to another ground station is approximately 270 milliseconds. This delay does not appear to be particularly noticeable or disturbing for visual communications¹³; however, it tends to complicate the problem of echo control for voice communications and it can severely reduce the efficiency of digital communications. Considerable work has been done on echo suppressors and echo cancellers and a Bell Laboratories' field trial evaluation concluded that satellite circuits equipped with echo cancellers furnish service of equivalent quality to long distance terrestrial circuits.¹⁴ Similarly, improved coding techniques show promise of increasing the efficiency of digital transmission. Unfortunately, both of these improvements will increase the cost of satellite communications to some degree.

As the demand for additional satellite circuits increases, a problem arises due to the potential overcrowding of allocated

frequencies in the lower frequency bands. Also there is only a limited area in space, commonly referred to as the equatorial geosynchronous arc, in which a satellite may be placed in a geostationary orbit. As the number of satellites in use increases, the physical space available in this arc will become extremely congested, particularly over North America and other highly developed areas. Fortunately, the use of higher frequency bands (11/14 GHz and 18/30 GHz) shows promise of helping to alleviate both the frequency and spacing problems. These higher frequency bands will not only provide a larger available frequency spectrum but will also allow the use of narrower beamwidth signals which in turn may allow a closer spacing of satellites than that now employed. In order to use these higher frequencies several problems must be overcome, including the attenuation effects of the atmosphere, but many optimistic forecasts indicate these problems can be solved.¹⁵

As indicated in Table III, the demand for and usage of satellite communication links has grown quite significantly since the launch of Early Bird. This trend is expected to continue well into the future and a need for nearly 3,700 35 MHz satellite transponders has been projected for the year 2002.¹⁶ Fortunately, forecasts of future satellite availability indicate this need can be fulfilled.¹⁷

This section has attempted to give some insight into the potential for communication satellites to provide economical wide bandwidth transmission links suitable for use by video teleconference systems. The next section will describe another approach being developed which has a similar potential.

Fiber Optics

Interest in the potential for transmitting large quantities of information on a light beam was aroused following the discovery of lasers in 1960 and the publication of a theoretical paper in 1966 demonstrating the possibility of low loss optical fibers served to further heighten this interest.¹⁸ In 1970 the Corning Glass Works produced optical fibers having losses under 20 dB/km and by 1974 laboratory experiments had achieved losses as low as 2 dB/km.¹⁹ By 1978 several commercial sources were selling optical fibers with losses less than 10 dB/km and laboratories were achieving attenuations of a fraction of a decibel per kilometer.²⁰ These low losses will allow repeaters for optical fiber systems to be spaced further apart than those currently used for conventional copper wire and coaxial cable systems.²¹ Thus, optical cables have the potential for being used either for local distribution facilities or for long haul transmission systems.

The most striking feature of optical fibers is their enormous capacity. In theory a single fiber has 3000 times the total bandwidth of the entire radio spectrum below 300 GHz.²² While this theoretical limit has not been reached, electro-optical and acousto-optical techniques are allowing bandwidths and bit rates up to GHz and Gb/s values.²³

Optical fiber cable prices are now becoming directly competitive with coaxial cable (\$1.00 per meter). Decreases in production costs and economies of scale should reduce these costs to approximately 10 cents per meter by the 1980's, which could make optical fiber cables cost competitive with copper wire cable.²⁴ Intensive research

being done on the transmitters, repeaters, modulators, and other equipment required for use with optical fiber systems is reducing the cost of these items as well. For example, a new 20 Mb/s full duplex fiber optic digital communication link designed to replace current data processing interconnection equipment is being offered by Canoga Data Systems for less than \$500, which is comparable to prices of current technology equipment.²⁵

Other advantages of optical fibers are their small size which reduces duct and manhole congestion, essential immunity to crosstalk and electrical interference, and expected lower maintenance costs.²⁶ Disadvantages include connector losses, difficulties in splicing in a field environment, and a relative fragility of the optical fiber, as compared to copper wire, during installation. Some techniques to overcome these disadvantages have been developed by Bell Laboratories²⁷ and other researchers are also working on these problems.

While the investment in the existing communications plant will prevent any immediate widespread proliferation of optical fibers, several systems are being used throughout the world. Table IV provides a representative sampling of countries and organizations engaged in research or use of optical fiber systems. In the United States, Bell Telephone has operated its Picturephone Meeting Service as well as other voice and data circuits on an experimental basis well over a year on optical fiber links within the city of Chicago.²⁸ Beginning in mid-1980, Bell also plans to use glass fibers and lasers between three central telephone offices in Atlanta, for its first standard lightwave communications system.²⁹ GTE and ITT also have plans for permanent optical fiber links for use with telephone exchange systems^{30,31} and Bell Canada has installed optical fibers for telephone

TABLE IV
OPTICAL FIBER SYSTEMS

United States

Bell Laboratories
GTE Laboratories, Inc.
GTE Service Corp.
U.S. Army
U.S. Air Force
U.S. Navy
NASA
Collins Radio
Harris Electronics
Xerox
International Telephone and Telegraph

Japan

Nippon Electric
Nippon Telephone and Telegraph
Nippon Sheet Glass
Fujitsu Laboratories

United Kingdom

Post Office Research Department
Plessey Telecommunications Research LTD.

France

Centre National d'Etudes Telecommunications
Compagne Generale d'Electricite

West Germany

Siemens AG
Standard Elektrik Lorenz
AEG Telefunken

Canada

Bell Northern Research
Northern Electric

(Source: U.S. Department of Commerce, Lowering Barriers to Telecommunications Growth.)

use in homes in Toronto.³² Bell Canada also used this test system in a demonstration of video teleconferencing with the British Post Office's Confravision studios in London.³³

Optical fibers appear to have a great potential for providing low cost, wide bandwidth transmission links suitable for video communications as well as voice and data communications. The next section will consider techniques which can be used to reduce the bandwidth requirement for video teleconference systems.

Digital Television and Bandwidth Compression

Digital transmission in the United States began over a century ago. However, innovation in this area progressed slowly for the next 60 years until the invention of pulse code modulation (PCM).³⁴ In recent years, digital transmission has been increasingly used and by the mid 1970's, the Bell System had developed a high quality nationwide digital transmission network.³⁵

On the surface, digital transmission appears to have a major disadvantage of requiring greater bandwidth than analog transmission systems. However, because the digital signal can be reconstructed at frequent intervals it can withstand transmission in a much poorer signal-to-noise environment than analog signals and on links with a wideranging trade-off between signal-to-noise ratio and bandwidth, a somewhat larger number of voice channels can be derived by PCM techniques than by analog techniques.³⁶ The cost of digital circuitry is dropping fast due to large scale integration technology. Another advantage is that all digital signals -- voice, data, and video -- become a stream of similar looking pulses.³⁷ It can be said that

digital transmission offers improvement in performance, flexibility, and cost and it also offers other advantages for television transmission.

Television transmission tends to be very inefficient because the ratio of nonredundant information delivered to the total information transmitted is very low most of the time.³⁸ By digitizing television signals it is technically and economically feasible to improve transmission efficiency and reduce bandwidth by removing redundant parts of the signal before transmission.³⁹ Much research has been conducted in this area, however, Bell Northern Research has published a rather comprehensive article on the subject and much of the following discussion is based on their work.⁴⁰

The amount of redundancy in a television signal can be reduced because of two factors. First the human eye has a limited ability to absorb information and thus cannot use the total amount of information that a video channel is capable of transmitting. Secondly, most pictures have relatively large areas of uniformity, i.e., background, which does not change or changes slowly in comparison with the rest of the picture. By transmitting only those portions of the picture that change (the difference signal) during each image frame a considerable reduction in data rate can be achieved. A further reduction can be achieved as well because it is possible to predict the frequency of occurrence of these difference signals. To reduce the number of bits necessary to represent a difference signal, very short codes are assigned to the difference signals predicted to occur most frequently and longer code words to those predicted to occur less frequently. Other portions of the television signal which are predictable are the horizontal and vertical retrace sweep intervals,

up to 23% of the transmitted signal. Most of this information can be eliminated, with a few digital bits being used to provide only that information absolutely essential for the receiver to remain synchronized with the transmitter. The receiver can also be designed to replenish one of the two interleaved fields that normally make up a transmitted image frame which will further reduce the data rate by 50%.

It should be noted that use of some of the techniques mentioned above may cause degradation of some types of fast moving pictures, for instance, hockey pucks were observed to disappear momentarily in some tests. However, it is felt that no degradation will be present for the types of pictures normally transmitted during video teleconferences. Since the removal of redundancy from a signal tends to make the remaining information more important, some form of error correction coding may be required for some types of transmission media when redundancy techniques are used.

The objective of Bell Northern Research is to reduce the data transmission rate of approximately 90 Mb/s to about 6 Mb/s which they feel will be sufficient to make video teleconferencing economically attractive for intercity service.

Another bandwidth compression technique being used in the Australian Post Office television facility is designed to provide the audio signal entirely within the video bandwidth by multiplexing it with the video signal.⁴¹ This technique uses the method of time division multiplexing the sound signal into the time slots provided in the video signal to allow for horizontal and vertical scanning retrace periods at the receiver. While this approach does not provide

results as dramatic as those tested by Bell Northern, it does provide some reduction in cost and it also simplifies the switching problems that can occur when multiple video teleconference facilities are connected together.⁴²

The previous three sections have concentrated on technologies which can reduce the transmission costs for video teleconference systems. The next two sections will discuss technologies which can be used to enhance the effectiveness of video teleconferencing.

Video Recording Equipment

Inexpensive video recording equipment has been promised for well over a decade; however, it was not until the late 1970's that systems were developed which provided simple and acceptable service at low costs. Now video cassette tape recording machines capable of recording four hours or more of television programs and costing less than \$1000 are popular items on the consumer market.⁴³ There are numerous manufacturers and distributors of these cassette tape machines and additionally some manufacturers are working on or have developed video disk systems, which operate similar to phonograph recording equipment. While there are four basic designs of the video tape machines, all of which provide acceptable quality, no standard has yet been set to insure compatability of recordings and it appears that this potential problem will be worked out by marketplace forces.⁴⁴ One deficiency of these systems is that with tape as a storage medium, linear search is required to find any desired storage frame, however, modifications to reduce the delay encountered are being tested.⁴⁵

Although video recording systems were developed with the "home"

television market in mind, it appears that they provide an excellent method of recording the interaction of video teleconferencing and will serve to enhance the effectiveness of these types of conferences.

Enlarged Video Displays

Another technology being developed with the consumer television market as the target is that of enlarged, flat panel video displays. The cathode ray tube (CRT) is the dominant video display method in use today. However, it appears that geometry precludes the development of large, flat displays using the CRT.⁴⁶ At the present time the only way to get television pictures larger than 25 inches to 30 inches diagonal, is by projection techniques. Some of these systems in use are producing displays with a diagonal measurement of over 7 feet at a cost of about \$3000.⁴⁷ Many other techniques are being developed with the potential for producing higher quality flat panel displays than those available through projection. Among these techniques are gas discharge, electroluminescence, passive devices such as liquid crystals, and thin-film transistors.⁴⁸ While none of these techniques are sufficiently developed to be placed on the market, the response to large screen projection displays seems to indicate that the large images produced have a significant impact on the viewer.⁴⁹ The potential for using large screen displays for video teleconferencing seems promising and as mentioned in Chapter II, they have already been used in some video teleconference systems.

The next section will consider some technological developments which may provide competition for video teleconference systems.

Interactive Cable Television

Cable television (CATV) systems in the United States have grown from 14,000 home subscribers in 1952,⁵⁰ to 13,000,000 subscribers by the end of 1977.⁵¹ The early function of CATV systems was to provide television reception to remote areas. However, as these systems have grown to include metropolitan areas as well, many additional applications have come under consideration. Because of the potential for some of these considered applications to improve the public welfare, an attempt to assist in their development resulted in a law requiring all CATV systems installed after 1972 to have two-way communications capabilities.⁵² While in concept, and occasionally in practice, these two-way CATV systems can support two-way video, primarily because of cost considerations, the term interactive CATV has come to represent a one-way video path with a two-way audio link.⁵³ Because interactive CATV systems do not meet our definition of video teleconference systems, they are not included in the primary emphasis of this paper. However, because of their increasing importance in providing communications for educational, health, entertainment, and other uses and because of their potential for competing with video teleconference systems, a sampling of some interactive CATV systems follows. Unless otherwise noted most of the following information is extracted from the study by the National Transportation Policy Study Commission.⁵⁴

The most well known interactive CATV system in the United States is operated by Warner Communications in Columbus, Ohio. This system, called Qube,⁵⁵ in addition to providing normal entertainment type programs also allows viewers the ability to respond to questions or

surveys. This response is somewhat limited in that they have a channel selection console with only a few response buttons, and therefore a limited response capability, which are connected to a computer which polls, tabulates, and initiates displays of viewer response. The computer also scans the 10,000 subscribers every six seconds for maintenance, billing, and program rating purposes. Warner Communications is considering expanding the functions of Qube to provide home security services and possibly the reading of utility meters over their two-way cable. It appears that the present system is increasing in popularity and Pittsburgh is the next targeted Qube market.

The United Kingdom has also done considerable work in the area of interactive CATV, and at present has two basic types of systems operating. The first type of system, termed Teletext, is not completely interactive but is in many ways similar to interactive systems. Teletext systems are designed to provide a continuous stream of information in graphic form which can be received on a home television via either broadcast or cable from a computer-centered data base. This data -- news, weather, etc. -- is arranged in the form of pages and transmitted during the scanning retrace periods which occur in normal television broadcasts. The viewer must scan the information flow and when finding something of particular interest, captures that information on his screen while the remainder of the information stream continues to be broadcast to other viewers. The second basic type of system, Viewdata, is normally received in a manner similar to that of Teletext but additionally is connected back to a central data base computer by cable or telephone line. This connection back to the central computer gives the viewer the capability to search

through information storage files at will and selectively capture and use what is desired without waiting for the system to scan its complete data bank before returning to that information desired by the viewer.

Another system called Vista⁵⁶ has been designed by Bell Canada and it operates very much like Viewdata.⁵⁷ The primary difference with this system is that the graphics display material is sent to the home television via standard telephone lines instead of in a cable or broadcast mode.

One of the most ambitious interactive CATV experiments is being conducted by Japan in an area called Tama New Town. In this new community, several hundred homes are provided with a coaxial cable which is connected to a television set and other devices. Users of this system can: watch regular, community, or pay television; read various types of news or information; generate facsimile hard copy of material transmitted by the cable; send memos to other system subscribers; request information from a data file; and respond directly to telecast questions or surveys.

The Japanese system probably comes as close as any yet implemented to creating what is often termed the "wired city" or "wired nation" in which every home, institution, and commercial establishment is connected to a broad bandwidth telecommunications system. The next section will discuss some other developing technologies which may speed the occurrence of the "wired nation" and which have a potential for complementing video teleconference systems.

Computer Teleconferencing

In the past 25 years, electronic computers have grown from

infancy into a prodigious industry. With the advent of miniaturized, low-cost, high capacity, digitalized equipment and techniques the capacity for generating, storing and manipulating vastly increased amounts of information has been created. The same technology which permitted the building of the computer has been extended into the design of terminal equipment and even the network links between these terminals and computers.

It is now possible to communicate person to computer, computer to computer, and person to person through a computer both locally and long distance. Because there are so many variations possible it is difficult to specify exactly what a computer teleconference system consists of but many would agree that the following elements are needed: CRT display as well as hard copy capability, keyboard entry terminal, computer with large memory capability, high capacity transmission links, and adequate software to assure compatibility between systems. The findings by the National Transportation Policy Study Commission are that:

With microprocessors becoming significantly more powerful, and with inexpensive, accessible memory approaching the terabit (one trillion bit) level, the early 1980's should herald the coming of a rather impressive array of multifunctional terminals--terminals which will have a color video display, a large memory, a high speed, non-impact color printer, an optical image reader for input without retyping, the ability to communicate with other terminals or terminal based message systems, and perhaps other features.⁵⁸

The uses for these computer based systems will cover a wide range of business, medicine, education, government, and home needs and the demand for these systems will continue to increase as new

consumer growth patterns emerge.⁵⁹ The one element these systems do not possess, however, is the capability to provide face to face discussion between human beings. Therefore, in an environment where that type of contact is desirable, computer teleconference systems will be used to complement and not compete with video teleconference systems.

This chapter has briefly discussed a few of the many technological developments which will have an impact on the future of video teleconference systems. The developments listed are by no means all inclusive of the many advances made in the space, optics, and electronics fields in recent years. Perhaps they will give the reader some feel for the rapid strides which have been made and are continuing to be made in these areas. Based on past accomplishments there is no reason to believe that technology shortfalls will limit the success of video teleconferencing.

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54. National Transportation Policy Study Commission, The Impact of Telecommunications.
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56. Vista is a registered Bell Canada trademark.
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CHAPTER IV

HUMAN FACTORS

"The greatest technical accomplishment in the world may go unused if it is not designed with people in mind."¹ Ironically, this quote is from a 1969 Bell Laboratories article on the Picturephone which was later to fail, according to some, because of Bell's failure to adequately consider human factors. Regardless of what actually was the major cause of the failure of Picturephone, human factors played an important part in the conception, design, implementation, and demise of the system. Likewise, human factors have and will continue to play an important part in the success or failure of any video teleconference systems. In recognition of the importance of human factors to the acceptance and utilization of teleconferencing, several major studies have been undertaken in an attempt to better understand how and why people respond to various person to person communication systems. Some of the factors studied which have a bearing on video teleconference systems, along with the results of these studies, will be discussed in this chapter.

Effectiveness

Effectiveness is usually the key word all researchers have used in outlining what objective their study was attempting to accomplish. Some studies have focused on the effectiveness of the design and layout of their equipment,² some on the effectiveness of one mode of

communication as compared to other modes,^{3,4} and some on the effectiveness of telecommunication as a substitute for travel.^{5,6} In most of the studies, the basic standard against which effectiveness is measured is the normal, unrestricted, face to face communication. In general the authors feel that face to face communications is an acceptable standard for measuring the effectiveness of video teleconference systems although it should be noted that some types of communications problems are solved nearly as quickly in voice-only modes of communications as in face to face communication.⁷ Another point that should be made is that the energy crisis may at some point change the criteria by which the effectiveness of video teleconference systems will be evaluated. If the shortage of energy should drive up the cost of travel so that it is much more costly than video teleconferencing, the criteria for evaluating video teleconferencing is likely to be "will it get the job done" rather than "is it comparable to face to face communication". For the present time, however, face to face communication will for the most part continue to be used as the standard for measuring effectiveness of communication.

Human Response

Some of the more basic research on communications and human response has been done by Chapanis.⁸ He began by considering the possible communications modes used in person to person communications and found that the list is surprisingly short. The following human skills are involved in communicating on a person to person basis: Body movements -- postures, gestures, and facial expression; speaking; writing; and typing. The mechanical or electronic counterparts of these human

skills are video, voice, handwriting, and typewriting. Using these counterpart modes of communication types, Chapanis observed the communications interaction of people as they attempted to solve both cooperative and conflictive problems. These problems were designed to be representative of tasks that are the subject of interactive conferences or meetings, or that might be addressed in such meetings. As would be expected, when comparing these communications modes, it was found that problems are solved significantly faster with modes that have a voice channel than with those that do not. Interestingly though, as previously noted, voice-only modes were nearly as fast in solving some problems as the voice and video mode or the face to face communication mode. This does not necessarily mean, however, that voice-only modes can be considered as effective as face to face communications. Also, unfortunately, Chapanis does not offer his opinion on whether a voice and video mode is as effective as face to face communications, although his results show nearly equal problem solving times for the two modes.

Other basic human responses to communications systems were discussed by Dickson⁹ in relation to the video telephone and some of these responses are also relevant to video teleconference systems. Furthermore, it appears that some of the human responses which may have had a negative impact on the video telephone will not greatly affect the use of video teleconference systems.

One of the factors which may have adversely affected the video telephone is privacy. While privacy includes concern with surveillance, secret files, computerized records abuse, and wire tapping, it also includes more fundamental considerations such as absence of intrusion, quiet, composure, and shyness. The audio telephone has

intruded upon human privacy to some extent since it allows virtually anyone to interrupt thoughts, conversations, meals, and many other personal activities at any time. Only the most disciplined will ignore the persistent ringing of the instrument. Telephone users have also learned to employ the invisibility of the telephone conversation by indulging in activities during a telephone conversation that might be considered rude in face to face contact, such as doodling, yawning, reading or writing on an unrelated topic, etc. The video telephone promised the capability to remove the advantage of invisibility inherent in the use of the audio telephone while retaining and even intensifying the disadvantages of unwanted and untimely intrusion into one's privacy. Video teleconference systems, on the other hand, will probably operate in a more controlled environment in which the body of etiquette developed around face to face business meetings will be utilized. Video teleconferences will likely tend to be scheduled affairs, like present business meetings, where each participant will have time to fully consider and prepare for the conference and thus will be able to make the encounter as advantageous as possible to their objectives.

Another facet of privacy discussed by Dickson is that in our culture, as well as all others, an unconscious yet universally recognized etiquette has been developed which determines what distances of personal approach are appropriate for different situations. In the United States, these have been characterized as: "Intimate", from contact to 18 inches; "personal", from 18 inches to four feet; "social", close phase, from four feet to seven feet; "social", far phase, from seven to twelve feet; and "public", above twelve feet. While most of the video telephones were designed for optimum viewing distances

of about three feet, thereby placing all contacts in the "personal" category, as might be expected, tests on video teleconference systems during actual conferences found the preferred viewing distance to be between eight and nine feet.¹⁰ This distance is in the "social", far phase, category and corresponds fairly closely to normal distances of participants in face to face conferences. This factor should be taken into consideration in the design of any planned video teleconference system.

Dickson also evaluated some of the potential effects of status and prestige on the acceptance of the video telephone and some of these observations will probably apply to video teleconference systems. Because the video telephone tended to force all users into the same distance category, it caused a diminishing awareness of many of the props normally arrayed to enhance social distinctions. Dickson suggested that for executives and managers at the top of an organizational hierarchy, the establishment of a rich, studio-like backdrop for video telephone use might restore some of the visual clues necessary for the awareness of social position. Some of these same motivations will undoubtedly be considered for video teleconference systems, especially if desk top systems are used. For studio based systems the corporate status, rather than the individual executive status, will be on display so it is likely that the video teleconference studio will be lavishly designed and furnished in order to present a positive image of the company.

One final consideration of the effects of status and prestige concerns the possible method of adoption of video teleconference systems. If the major thrust for adoption and use of video teleconference

systems initially comes from the top of the organizational hierarchy it is possible these systems could be viewed as status symbols, and like the executive jet, would only be required to save time and increase the prestige of the user. If, on the other hand, adoption begins by members of middle management as a means to expedite or alter the nature of their work, the video teleconference system will probably have to meet a stricter test based on economic justification.

In the United Kingdom, more advanced research on communications and human response has been accomplished by the Communications Studies Group (CSG) under a contract with the Post Office and Civil Service Departments.¹¹ They focused their attention on the effectiveness of different communications media relative to the face to face meeting; the acceptability of different commercially available and prototype systems as substitutes for the face to face meeting; the numbers and types of face to face meetings that now take place in different organizational contexts; the scope for different classes of systems as substitutes for face to face meetings; and other topics not pertaining to this chapter.

The CSG found that the basic functions of meetings were discussions of problems and ideas; information exchange; negotiation; task allocation and delegation of work; report presentation; discipline and dismissal of employees; policy making; and getting to know someone. The functions generating most meetings were sales, industrial production, research and development, exports, and office administrative activities. Not surprisingly, the number of meetings generated by an activity was found to be directly dependent on the number of senior personnel present -- those who are in a position of responsibility

and are required to engage in sensitive extramural contacts.

The CSG also found that the type of communications medium had little affect on situations where there is not much need for two-way communication such as information transfer and in two-way tasks where there is little conflict and where personal relationships are not relevant. The type of communications medium did have a large impact on meetings involving conflict and those involving interpersonal relations. They generalized their findings on the effectiveness of different communications media by saying that "video conditions gave results intermediate between those obtained in the audio condition and face to face".¹² They also found that in some cases where visual information was relevant, such as assessing others' opinions, video conditions represented an appreciable improvement over the audio only condition. While video systems provide more social contact than audio only systems, there are still some situations requiring high degrees of personal contact (such as disciplining employees) in which face to face remains the preferred medium. As to the acceptability of available and prototype communications systems, CSG says, "...laboratory video systems are the subject of very positive feelings, a finding which has been replicated on three real-life systems...".¹³

As mentioned previously some researchers have focused on the effectiveness of telecommunications as a substitute for travel. This subject will be covered in more detail in the next chapter with emphasis on economic factors. However, in passing, it should be noted that human factors do have a significant bearing on why people travel. In some respects the willingness for people to substitute telecommunications for travel seems to closely follow the perceived effectiveness of

communications systems to substitute for face to face meetings. In this context, one study found that only 3% of travellers would be willing to consider substituting with a system that did not have a video capability. On the other hand another study found that 3% of travellers would not consider substitution at all because they wanted to get away from the routine of the office.¹⁴ On a lighter note, some travellers also desire to continue travelling because of non-business activities associated with the trip and there are some activities for which there are no electronic substitutes. For instance, one respondent to a study indicated one of the non-business activities engaged in while travelling was meeting friends but replied "censored" when asked about the most satisfactory aspect of the trip.¹⁵

Physical Aspects

Based on the previous discussion of the etiquette of social distances, it is obvious that physical aspects of video teleconference system design and layout can have a bearing on the acceptability and effectiveness of these systems. Bell Laboratories has published the results of some of their work regarding the design of the conference facility, position and method of usage of cameras and microphones, optimum viewing position and angle of conference participants, and resolution capabilities of the video system.¹⁶ Some of this work is reviewed in the following paragraphs.

One of Bell's experiments compared the acceptability of a single curved table arrangement divided conceptually, not physically, into three sections (see Figure 4) with an arrangement of a set of three

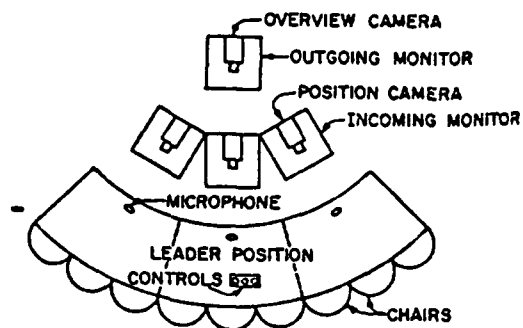


Figure 4. Curved Table Arrangement.

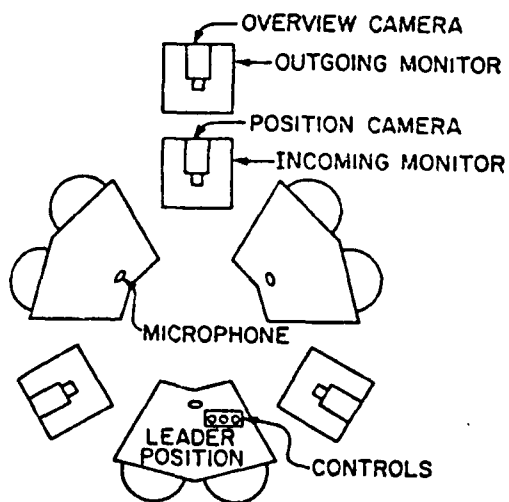


Figure 5. Circular Table Arrangement.

separate tables placed in a circular fashion (see Figure 5). These facilities provided three viewing monitors, each with a camera, for the participants along with a single overview camera mounted on the outgoing monitor. Also a single camera for use with graphics was provided at each facility. Microphones at each position activated the corresponding camera so that when a participant began to speak his picture was transmitted to the other facility and also appeared on the outgoing video monitor. If no one spoke for a short time the overview display was provided in either a panning mode or in a wide angle "fisheye" mode. Reaction to both of these facilities was enthusiastic with 98% reporting the system good or excellent. It was determined that the three table circular arrangement with a panning mode overview was slightly favored by the participants, although not to any significant degree. It is likely that since either of these arrangements are aesthetically acceptable that technical considerations will determine which is primarily used for future video teleconference systems. Results of the test also indicate that the use of voice activated camera switching (with cough buttons to disable the microphone when desired) is well accepted.

In their study of user preferences regarding camera and monitor parameters Bell found, not surprisingly, that the preferred positions correspond fairly closely to what is normally found in face to face conferences. Most participants preferred to have the camera placed approximately at eye level (46 inches) and about 104 inches from the subjects. Similar height and distance positions were desired for the monitors and a viewing angle of 30 degrees or less from the monitor was preferred.

Bell's study of resolution and screen size preference was not very comprehensive in that only 1 MHz and 4.2 MHz bandwidth systems were tested on screen sizes of 7, 17, and 23 inches. However, it is possible to generalize the findings by stating that,

ratings of a 1 MHz bandwidth video conferencing facility made by participants in simulated conferences were less enthusiastic than those by participants using a 4.2 MHz facility.¹⁷

Similarly the users of the small screen were less enthusiastic than users of the large screen and in the case of graphics found the small screen to be completely unacceptable.

Familiarity

One of the human factors that has a bearing on the acceptability of video teleconferencing is the familiarity of the participants with this type of activity. One study found that

one of the basic hindrances to the growth of telecommunications usage by institutions is the lack of enough examples of actual advanced telecommunications systems.¹⁸

The lack of familiarity with video teleconference systems was revealed by the fact that 68% of the participants in SBS's Project Prelude teleconferencing demonstrations had little or no familiarity with teleconferencing at all.¹⁹ Another example is that Bell Laboratories found that low utilization of video conferencing facilities was partly caused by people planning meetings that were not easily adaptable to video conferencing.²⁰ The study by the CSG found similar results and concluded that the time it takes people to adjust their behavior to a new situation was a factor in low utilization of

equipment in the CSG's field trials.²¹

There is another facet to the effects of familiarity that concerns what most people are very familiar with -- network television. Almost everyone is well accustomed to the highly professional technical skills of network television announcers and camera crews, particularly in the areas of news and sports. The capability for zoom lens telephoto shots, split screen views, and instant replays is now completely taken for granted by most viewers. Consequently when some of these special effects and professional skills are absent from video teleconference systems, negative feelings can result. The authors observed this effect during the previously mentioned NOAA test on June 15, 1979. While no criticism of the technical crew is intended, there were times during this test when due to lack of familiarity with the system, graphics were not displayed to the best advantage and occasionally the cameras failed to switch to the speaker in a timely manner. While none of these actions were seriously detrimental to the purposes of the conference they were slightly distracting and they served to remind us as to how accustomed we have become to the high technical quality of network television.

Fortunately, there is a way to overcome the effects of both facets of familiarity on the human responses to video teleconference systems -- usage. This has been demonstrated quite dramatically during an evaluation of potential community uses of two-way cable in Reading, Pennsylvania.²² In this test, senior citizens who had no previous experience, were able to rapidly increase their skills in operating the system and were able to master not only the technical details, but were able to prepare and present complete television programs as well. Similar results can be expected as users gain more

experience in the operation of video teleconference systems. We would do well to consider that just as most cannot match professional sportsmen at their skills, most video teleconference system users probably will not be able to match the professional technical skills of network television. This situation, however, has not deterred people from participating in and enjoying sports and it should not deter people from the effective use of video teleconference systems.

In this chapter, some of the human factors impacting on video teleconference systems have been considered. While the understanding of human responses is not now and probably will never be complete, it seems obvious from the numerous and complex events occurring in this century that man has a high capacity to adjust to technological change. The possibility of the implementation and widespread use of video teleconference systems appears to be merely one more technological step in a continually changing world. Undoubtedly video teleconference systems usage will evoke many human responses not yet considered but it is unlikely that any of these responses will be so negative as to prevent this usage. More likely is that man's adaptability will allow the implementation of new uses for video teleconference systems not yet envisioned.

FOOTNOTES

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CHAPTER V

VIDEO TELECONFERENCING:

A SUBSTITUTE FOR BUSINESS AND GOVERNMENT TRAVEL

"Much passenger travel, especially for business purposes, is undertaken to allow the exchange of information..."¹ A study of the air passenger market in the New York area in 1967, for example, found that 57% of all air trips were for business purposes.² Telecommunication systems, which are simply electronic information exchange systems, can provide a more efficient and cost effective alternative to this travel. This is particularly so with video teleconference systems, since they can simulate the face-to-face contact which most businessmen consider important for business meetings.³

More efficient and less costly -- these are the claims being made for video teleconferencing. Is it possible? Greater efficiency (in terms of time) was alluded to in the previous chapter. To quote from another source, "video teleconference meetings differ from the traditional business meetings they replace in that they tend to be shorter and more businesslike..."⁴ One study estimated the time efficiency factor of video teleconferencing to be about 70%.⁵ The efficiency factor of video teleconferencing becomes even more pronounced when reduced time away from the job and the elimination of travel fatigue are considered. But is video teleconferencing less costly than business travel conducted for the same purpose? Admittedly,

this depends upon the organization, its travel profile,⁶ and the video teleconference system in question. But, in general, the answer is that it can be.

The purpose of this chapter is to explore the cost effectiveness of video teleconferencing as a substitute for business and government travel. First we will review past studies involving the degree of travel substitution possible. Next, we shall look at two attempts which have been made to analyze the economic tradeoffs between video teleconferencing and traditional business travel. Finally, we will present a step-by-step method by which business managers can evaluate the potential cost effectiveness of video teleconference-travel substitution for their organizations.

The Degree of Video Teleconference-Business Travel Substitution

The question which has raised the most controversy and stimulated the greatest amount of research surrounding the video teleconference-business travel substitution issue is: to what degree can video teleconferencing effectively substitute for business travel? It is obvious that video teleconferencing cannot substitute for all business travel. It is equally obvious that it can substitute for some. But how much is some? Many studies have been made in attempt to answer this question. While specific substitution potentials will vary from organization to organization, it is useful to review these studies to become acquainted with their methods and familiar with their results.

One has to be extremely careful regarding the results of these studies, because researchers sometimes confuse estimates of *substitution* with estimates of *substitutability*. The latter refers to an upper

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bound potential for substitution, while the former refers to the actual amount of travel which will probably be substituted for.⁷ Substitutability estimates are based upon travel profiles and the availability of effective video teleconference substitutes. The extent to which businessmen can be expected to actually modify their travel (substitution), is based, additionally, on political, environmental, social, and economic factors. Thus, the purpose, mode, distance, and number of people traveling may qualify a trip as substitutable, but the higher cost of a video teleconference substitute, or the fact that the meeting is set for Honolulu, Hawaii may preclude it from actually being substituted. There are other differences between substitution and substitutability estimates. Substitution estimates can vary drastically with the social, political, environmental, and economic climate of the time. Substitutability, on the other hand, will vary only with improvements in the effectiveness of video teleconferencing. The distinctions between substitution and substitutability will become increasingly important in later sections of this chapter. Thus, in the discussion of past video teleconference-travel substitution studies which follows, the type of estimate will be clearly identified.

For the most part, past research regarding the potential degree of video teleconference-business travel substitution has employed four methods.⁸

- (1) Intuitive judgement
- (2) Surveys
- (3) Field tests
- (4) Model building using survey data

The first of these methods, intuitive judgement, uses various trip purposes and other trip data identified in travel surveys to estimate substitution potential. This method will be discussed further in the final section of this chapter. Methods (2) through (4) are discussed below.

Surveys of actual business travelers, in which the traveler is given a hypothetical choice between video teleconferencing and his current travel, have helped to shed some light on the business travel-video teleconference substitution issue. The most detailed study of this kind was conducted by the Business Planning Group of Bell Canada in October 1973, just prior to the 1973-1974 Oil Embargo. A total of 26,000 questionnaires were distributed to businessmen traveling between five Canadian cities; 9616 questionnaires were returned. The results indicated that 20% (substitution estimate) of those surveyed would not have taken their trips if a full video teleconference system had been available.⁹

Another survey, conducted by Frank W. Snyder, Bell Laboratories, New Jersey, yielded different results. Fifty percent (substitutability estimate) of those surveyed by Snyder indicated that they could have satisfied their travel requirements with an audio-video teleconference system. Additionally, it was indicated that this substitutability estimate would increase if facsimile were added as an adjunct. And, as pointed out in a previous chapter, only 3% of those surveyed in Snyder's study were willing to consider using a remote transmission facility unless it provided a full video capability.¹⁰

Field trials, the second method employed by researchers, provide the most accurate figures regarding the amount of video teleconference-business travel substitution possible. Unfortunately,

these figures are applicable only to the organization in question. This combined with the fact that few field trials have actually been conducted, makes it difficult to generalize about the entire business travel substitution issue based on their results. Three field trials will be discussed here.

As mentioned in Chapter II, NASA currently operates a telefacsimile conference network. NASA officials estimate that this system has reduced total travel requirements by 17% (substitution estimate.)¹¹ A full video system could obviously provide even greater savings. Based upon their experience with Picturephone Mod II in 1969, the Westinghouse Corporation estimated that 20% (substitution estimate) of their travel could be eliminated. Finally, Dow Chemical officials boast that their CCTV system has eliminated 3500 trips and saved 52,000 person-hours annually. The benefit cost ratio for this system has been estimated at 2:1.^{12,13}

Realizing the shortcomings of the intuition, field trial, and survey methods for estimating business travel substitution, some research groups (Tyler, Cartwright, and Collins) have attempted a more sophisticated approach -- model building using survey data.¹⁴ The survey data used is based on behavioral research. Unfortunately, no specific results of studies using this approach could be obtained.

Studies conducted in Europe are worthy of mention also. One study, performed in Sweden, estimated that 52% (substitutability estimate) of business travel could be replaced by video teleconference systems. Similar studies in the United Kingdom and Germany yielded potentials of 50% and 62% respectively (substitutability estimates). In addition, the U.K. study projected a substitution estimate of 36%.¹⁵

Table V summarizes the research which has yielded results in the travel *substitution* category. Table VI summarizes those studies which have stated their results in terms of travel *substitutability*. Of those listed, the average substitution potential for animated video systems is 25.3%, while the average substitutability estimate is 53%.

The travel substitution/substitutability research just discussed was conducted in the 1972-1974 time frame. Both substitution and substitutability estimates are time sensitive and can be expected to vary with time and changing circumstances. Given the radical changes which have occurred in the areas of energy, fuel costs, social and environmental issues, and video teleconferencing itself, over the past six to eight years, it is very likely that the estimates listed in Tables V and VI are vastly understated. Thus, it will be useful at this point, to examine some of these changes and their effect on the validity of the results of past research.

To begin with, past estimates of substitutability are no doubt understated due to improvements which have been made in video teleconferencing. Recall that substitutability estimates are based, in part, on the availability of an effective video teleconference substitute. In 1973, most video teleconference systems were video telephone systems or prototype CCTV systems. In contrast, today's video systems are much more sophisticated, offering a range of features including large screens, full, animated color, high speed and low speed facsimile, video cassette recording and more. Certainly today's systems can effectively substitute for more business travel than those available in 1973.

TABLE V

RESULTS OF PAST VIDEO TELECONFERENCE-BUSINESS TRAVEL RESEARCH:

SUBSTITUTION ESTIMATES

Research Source	Method	Substitution Estimate
Business Planning Group - Bell Canada	Survey	20%
NASA Telefacsimile Conference System	Field Trial	17%
Westinghouse Picturephone Mod II Test	Field Trial	20%
British Post Office	Field Trial	36%

TABLE VI

RESULTS OF PAST VIDEO TELECONFERENCE-BUSINESS TRAVEL RESEARCH:

SUBSTITUTABILITY ESTIMATES

Research Source	Method	Substitutability Estimate
Snyder Bell Laboratories	Survey	50%
British Post Office	Field Trial and Survey	50%
FTZ Darmstadt Germany	Survey	62%
Elseruis Sweden	Survey	50%

Changing factors have also had an effect on the validity of past substitution estimates. As mentioned before, the extent to which businessmen will actually substitute video teleconferencing for conventional travel depends, in part, on political, social, environmental and economic considerations. The political, social and environmental tradeoffs between video teleconferencing and travel will be considered in detail in the next chapter. For now, however, consider the fact that public and political concern for such factors as pollution, the ecology, and resource and energy consumption has heightened in recent years. At the same time, businesses have become increasingly aware of and sensitive to their social responsibilities.¹⁶ These factors serve to increase the likelihood that businesses will substitute video teleconferencing for travel.

The greatest impact on substitution potential, however, has come from changes in economic factors -- specifically changes in the relative costs of travel and video teleconferencing. The cost of telecommunications in general, and of video teleconferencing in particular, has been reduced significantly over the past six years.¹⁷ As mentioned in a previous chapter increased use of fiber optics and satellites is expected to reduce these costs even further.

On the other hand, fuel and travel costs have soared. In 1973, the United States paid an average of \$3.94 a barrel for the crude oil it consumed; by 1976, this cost had risen to \$10.54 per barrel,¹⁸ an increase of more than 267%. From 1976 to 1978, the price jumped to \$12.75 a barrel.¹⁹ Then came the revolution in Iran and domestic crude oil price deregulation. In March of 1979, the OPEC countries raised the price of crude oil to \$14.55 a barrel, a 14.5% increase

over the previous year's price. Just three months later OPEC again raised its price; this time to \$18.00 a barrel, and it authorized surcharges which would allow charges of up to \$23.50 a barrel on the spot market.²⁰ As a result of this latest increase, the U.S. is now paying between four and six times more for imported crude oil than we did in 1973.

Since four out of every ten barrels of crude oil used by the U.S. today is imported,²¹ the impact of these higher prices on domestic fuel and transportation costs has been significant. Diesel fuel prices increased 8.1% in May alone.²² Gasoline prices have increased an average of 144% in the past six months. Jet fuel is also becoming scarce and more expensive. The airlines are expected to raise the price of air fares 10 to 15% by October 1979, while simultaneously reducing the number of flights now scheduled.²³

Since the actions of businessmen are theoretically governed by the profit motive, higher fuel and travel costs coupled with lower video teleconferencing costs can only result in an increased willingness, on their part, to substitute for travel. This is especially the case when the radical changes in the social, political and environmental factors influencing travel substitution are considered. The conclusion here is that both travel substitution and substitutability estimates from past research are understated for today's purposes.

Review of Previous Economic Analyses

The research regarding business travel substitution just described predicted the potential amount of travel which could and would be replaced by video teleconferencing. How much of this potential is actually realized will depend for the most part on the relative costs

of travel and video teleconference systems. Several studies have been made in an attempt to analyze the cost effectiveness of video teleconferencing as a travel substitute. Two of these will be reviewed here.

In 1973, Edward Dickson attempted an economic analysis of the costs to substitute long distance video telephone calls for business air travel. His approach was as follows:

- (1) Calculate the cost of traveling between the two conference points, including the cost of a round trip airline ticket, meals and overnight lodging, and the opportunity cost of time lost by conference participants, away from the job.
- (2) Determine the cost of a Picturephone telephone call between the same two locations, on a per minute basis.
- (3) Calculate the number of Picturephone minutes obtainable at a cost equal to the cost of travel.
- (4) Determine whether the number of equivalent Picturephone minutes is ample to accomplish the conference task.

Based upon his analysis, Dickson concluded that a businessman would have to value his time at a minimum of \$40 per hour (the equivalent of \$83,000 per year) in order to justify using a Picturephone in lieu of travel. Dickson further concluded that at the rates then projected for intercity video telephone service, air travel would cost less than a video call that lasted long enough to accomplish the same task.²⁴

In 1974, the British Post Office sponsored a travel substitution cost analysis in conjunction with the Communications Studies Group, University College, London. Their approach was as follows:

- (1) Calculate the cost of travel between the two conference locations to include travel cost by rail, air, and private auto; cost of lost time for conference participants; and lodging and food.
- (2) Estimate the number of people required to travel.
- (3) Estimate the duration of the meeting. (The duration was assumed to be the same for video teleconferencing as for the face-to-face meeting.)
- (4) Determine the per hour cost of Confravision between the two conference locations.
- (5) If the number of people traveling to the meeting multiplied by the total cost per person for travel is greater than the duration of the meeting in hours multiplied by the per hour cost of Confravision, then Confravision can be said to be less expensive.

The study concluded that for rail travel, the viability of Confravision as a substitute was independent of the distance of the trip, and thus depended only on the value placed on conference participants' time, the duration of the meeting, and the number of people traveling. Also, for long distances, air travel was found to be more economical than Confravision.²⁵ Finally, the BPO study said this:

...it would appear to be true that, at present, narrow-band telecommunication is a great deal more economical and broad-band communication less economical than travel to a face-to-face meeting.²⁶

Like the substitution studies described in the previous section, the cost analyses performed by Dickson and the British Post Office are out of date. They are, however, the most recent analyses that could be found, and they are typical of those performed in the 1973-1974 time frame. The following is a list of the reasons why we

consider these analyses inadequate and not suited for today's purposes:

- (1) The purchase of a video teleconference system was not considered as a viable alternative.
- (2) No consideration was given to the time value of money.
- (3) The effect of income taxes was ignored.
- (4) Both studies were centered around a single video teleconference system.
- (5) The video teleconference systems used are out of date, in terms of features and effectiveness.
- (6) The cost of these systems is also out of date and was based upon transmission costs only.
- (7) The cost of travel is out of date, and was assumed to remain constant over time.
- (8) Both analyses were single trip oriented, and did not consider the probable impact of video teleconferencing on total travel requirements.
- (9) Non-quantitative and human factors were not considered.
- (10) A potential user could not use the methods of these analyses to evaluate the potential cost effectiveness of video teleconferencing for his organization.

Original Cost Analysis:

A Model for Business and Government Managers

In an attempt to overcome the shortcomings of the analyses listed above, we have devised a new method for evaluating the potential cost effectiveness of video teleconferencing as a substitute for business travel. Above all, our method is designed so that the business manager can use it as a model to evaluate the cost effectiveness of using video teleconferencing to replace travel in his organization. We assumed

that two basic types of video teleconference alternatives will be available to the businessman in the near future -- the first is Picturephone Meeting Service, and the second is a privately-owned CCTV system. Since the economics of these two systems are entirely different, two distinct methods of analysis are necessary.

Evaluating the Cost Effectiveness of Picturephone Meeting Service

Picturephone Meeting Service must be evaluated on a case by case basis, i.e., a separate analysis must be made for each travel meeting proposed. The recommended approach is as follows:

- Step One: Calculate the after tax cost of the proposed travel between the two conference locations, including transportation costs, meals and overnight lodging expenses, and the cost of time lost by those traveling away from the job.
- Step Two: Estimate the amount of conference time which will be required for the face-to-face meeting.
- Step Three: Multiply the time estimated in Step Two by a video teleconference efficiency factor. (Recall that video teleconferencing has been shown to require less time than face-to-face meetings for the same purpose, and that one study estimates the efficiency factor to be 70%.)
- Step Four: Determine the after tax cost of using Picturephone Meeting Service as an alternative. First, determine the cost and availability of using PMS between the two conference locations on a per minute basis (see Table VII), and multiply by the time computed in Step Three. Second, add the cost of traveling to and from the PMS studio.
- Step Five: Compare the costs. If the cost estimated for using Picturephone Meeting Service is less than the cost of travel, PMS is a cost effective alternative.

Of course, this method presupposes the fact that the proposed trip

TABLE VII

SAMPLE COSTS FOR PICTUREPHONE MEETING SERVICE

Locations	Cost (per minute)
San Francisco to New York	\$6.50
San Francisco to Washington, D.C.	\$6.50
Los Angeles to New York	\$6.50
Chicago to New York	\$4.50
Chicago to Washington, D.C.	\$3.50
New York to Washington, D.C.	\$2.50

has been determined to be substitutable. Guidelines for doing this will be presented later in this chapter.

The following example will serve to illustrate our procedure for analyzing the cost-effectiveness of Picturephone Meeting Service. Suppose that a business trip is planned between San Francisco and Washington, D.C. Three people will travel, and the trip will require two days, of which one day is dedicated solely for travel. The average salary of those expected to make the trip is \$32,000 per year. Is Picturephone Meeting Service a cost effective alternative to the proposed travel?

Step One: The cost of travel is as follows:

Round trip air fare (3 @ \$468)	\$ 1404
Meals and lodging (3 @ \$100)	300
Lost time away from job (3 @ \$121 per day for 2 days)	727
Before tax total	\$ 2431
After tax total (assuming 40% bracket)	<u>\$ 1749</u>

Step Two: The amount of conference time required for the face-to-face meeting is estimated at 4 hours.

Step Three: The amount of PMS conference time required is then estimated at 4 times 0.70, equal to 2.8 hours, or 168 minutes.

Step Four: PMS is available between these conference locations at a cost of \$6.50 per minute. Thus the estimated cost of PMS is 168 minutes times \$6.50 which equals \$832. If the distance between the PMS studio and work locations is estimated at 15 miles for each end, the cost of traveling to and from the PMS conference center can be estimated as follows:

Private auto travel (@ 10¢/mile)	6.00
Lost time away from job (6 people @ 25¢/minute for 40 minutes)	60.00
Total	\$ 66.00

Thus, the total before tax cost of using PMS is, then, $\$832 + \$66 = \$898$.

The total after tax cost of PMS is therefore \$538 (assuming a 40% tax bracket).

Step Five: The cost of travel is equal to \$1749. The cost of PMS is \$538. Therefore, PMS is the most cost effective method for conducting the proposed business meeting.

Evaluating the Cost Effectiveness of a Privately-Owned CCTV System

When considering a privately-owned, studio based, CCTV video teleconference system as a travel alternative, the method of cost analysis is entirely different and somewhat more complex. Whereas a PMS system must be evaluated on a trip by trip basis, a privately-owned system must be evaluated on its potential to substitute over a wide range of travel alternatives, over a period of several years. Whereas a PMS system can be evaluated using current dollars, the costs of a private system and the associated travel alternatives must be discounted over the life-cycle of the system. Finally, from a pure business standpoint, the cost analysis for a private system must consider the effects of depreciation expenses and income taxes. It should be noted, however, that the effects of depreciation and income taxes do not apply to government agencies.

The method which we propose for business managers to use in evaluating the cost effectiveness of a privately-owned video teleconference system to replace travel is as follows:

Step One: Examine past and projected travel budgets in detail to determine which trips could be replaced by remote video teleconferencing. Guidelines for doing this are included later in this chapter. For now, consider the fact that most video teleconference systems today are capable of conferencing only two simultaneous locations. Thus consistently large

numbers of trips between the same two locations should be considered as prime substitution targets.

Step Two: Determine the cost of the travel that can be substituted for in today's dollars.

Step Three: Choose a video teleconference system which will effectively provide the substitution potential predicted.

Step Four: Determine the costs of this system to include cost of purchasing equipment, transmission costs, installation, and maintenance, all in today's dollars.

Step Five: Perform an economic analysis between the cost of the video teleconference system chosen and the cost of the travel to be replaced. This analysis should be performed over the life-cycle of the video teleconference system, and should include the effects of depreciation and income taxes (not applicable to government agencies), and an allowance for increasing travel costs in years to come.

To illustrate this procedure, consider the following hypothetical example. Company A has annual travel expenses of \$300,000. Of this amount, \$150,000 is spent on travel between Los Angeles and Washington, D.C. A business manager wishes to investigate the possibility of using video teleconferencing to substitute for a portion of the Los Angeles to Washington, D.C. travel. The following analysis applies.

Step One: In reviewing past and projected travel budgets, the company executive estimates that approximately 35% of his future trips between Los Angeles and Washington, D.C. could be replaced by a suitable video teleconference network.

Step Two: For simplicity, it is assumed that the cost of these trips, in today's dollars, is \$52,500 (35% of the \$150,000 currently spent for travel between Los Angeles and Washington, D.C.).

Step Three: A system is chosen that will effectively substitute for this travel. For the purposes of this

example, two systems are chosen, to provide a perspective on the range of system costs involved. The first system is a "bare-bones" system and the second system is a more elaborate, full-feature system. Descriptions of these systems can be found in Appendix A and Appendix B.

Step Four: Appendix A and Appendix B also detail the costs of these systems in today's dollars.

Step Five: An economic analysis is performed using the costs determined above. For the purposes of this example, the following is assumed: a seven year system life-cycle, a 25 percent value of money; straight line depreciation over the entire seven year period with no scrap value; a 40 percent corporate income tax bracket, and an annual inflation rate of 10 percent. The costs of system maintenance and travel were considered to rise with the rate of inflation, while the cost of broadband transmission was assumed to remain constant over the entire life of the system.

Based upon the analysis described in Step Five above, the total life-cycle cost of the bare-bones video teleconference system is \$99,949. The total life-cycle cost of the full-feature system is \$146,253. The total life-cycle cost of the substituted travel is \$126,753. Thus, the bare-bones system is cost effective, but the full-feature system is not, in this particular case.

Before moving on to the next section, let's pause for a moment to review the appropriateness of the cost data used in this example and to place this data into perspective. First, recall that travel expenses which could be saved between Los Angeles and Washington, D.C. were assumed to be \$52,500. If this seems high, consider that NASA has estimated that their telefacsimile conference system saved about \$4.1 million in travel expenses in 1971, and that Dow Chemical officials have stated that their CCTV system saved \$1.4 million in

travel expenses in 1973.²⁸ The point here is that there are certainly many companies capable of saving upwards of \$52,500 in travel expenses annually.

Table VIII lists the total discounted life-cycle cost of travel, based upon selected dollar costs of travel between two points and a 35% substitution potential. The breakeven point for the bare-bones video teleconference system occurs at about \$120,000 and the breakeven point for the full-feature system is somewhere around \$175,000. Anything above these amounts (travel expense-wise) would be cost effective. In addition, it should be noted that there are a wide range of systems, at different costs, between the two systems we have listed.

The life-cycle costs of our systems were computed to be \$14,278 and \$20,893 per year, respectively. To help to further put these costs into perspective, consider how much actual travel these systems could replace at these costs. Our example dealt with travel between Washington, D.C. and Los Angeles. The cost of a one-man, two day business trip, by air, between these locations is as follows:

Round trip air travel --	\$468
Meals and Lodging --	100
Lost time away from the job --	242
Total --	\$810
Less income tax break --	227
Effective after tax cost --	<u>\$583</u>

When the effective after tax cost of \$583 is discounted over the seven year life cycle used previously, the effective average cost per trip becomes \$328. Thus, at an annual expense of \$14,278, the bare-bones system would only have to substitute for about 44 one-

TABLE VIII
DISCOUNTED TRAVEL COSTS BETWEEN TWO POINTS

Total Point to Point Travel Costs (Today's Dollars)	Proposed Cost* Savings (Today's Dollars)	Total Discounted Cost Savings	Discounted Cost Savings/Year
\$ 80,000	\$ 28,000	\$ 66,250	\$ 19,464
\$120,000	\$ 42,000	\$ 99,400	\$ 14,200
\$150,000	\$ 52,500	\$126,753	\$ 18,107
\$180,000	\$ 69,300	\$149,049	\$ 21,292
\$200,000	\$ 70,000	\$165,553	\$ 23,650

* Based on 35% substitution potential.

person, 23 two-person, or 15 three-person trips per year to break even. The full-feature system, costing \$20,893 annually, would only have to substitute for 64 one-person, 32 two-person, or 21 three-person trips a year to be cost effective. Again, as a reference point, recall that more than 3500 round trips were made by Dow Chemical employees between Freeport, Texas and Midland, Michigan in 1973.

Finally, note that the usage time of the bare bones system was estimated at four hours per week, and the usage time for the full-feature system was estimated at six hours per week. The difference is due to an assumption, on our part, that a company which can afford a full-feature system will probably be larger than a company purchasing the bare-bones system, and therefore will be able to effectively use the system to a greater degree. Although four and six hours per week may not seem like much time, these figures are in line with those stated by current video teleconference users. Further, when the efficiency factor is considered, the numbers appear more realistic. At a 0.70 efficiency factor, four hours of video teleconferencing equates to almost six hours of face-to-face contact, while six hours of video teleconferencing equates to between eight and nine hours of face-to-face contact.

Non-Quantitative Variables

The analyses presented above deal with the video teleconference-travel substitution issue from a pure economic point of view. As with any cost analysis, however, there are a number of non-quantifiable variables which must be considered. Those variables which we feel are most important in the case of video teleconferencing are listed:

Positive Variables

1. Video teleconferencing is more businesslike and to the point.
2. Video teleconferencing is more timely.
3. Video teleconferencing eliminates travel fatigue.
4. Video teleconferencing allows more people to participate, both directly and indirectly, as would otherwise be possible with travel.
5. Video teleconferencing can be regarded as an organizational status symbol.
6. Video teleconferencing reduces the hardships of family separation.
7. Video teleconferencing has the advantage of increased safety.
8. Video teleconferencing saves energy.

Negative Variables

1. Video teleconferencing removes some of the advantages associated with a break in office routine.
2. Video teleconferencing removes the advantages of social interaction, away from the conference table.

In the end, consideration of these non-quantitative variables may provide the deciding factor for rejecting or adopting a video teleconference system within an organization.

Guidelines for the Business Manager in Estimating Travel Substitutability and Substitution Potential

Both cost analysis methods (PMS and Privately-Owned) outlined above require the business manager to make an estimate regarding the substitution/substitutability potential of his travel. It is envisioned that this may be the most difficult task facing the business manager in conducting his analysis. For the most part, the business

manager must rely upon intuition in arriving at these estimates.

There are, however, some general guidelines which can be offered to aid him in arriving at a reasonable figure.

First, as already mentioned, the business manager must not rely too heavily on the validity of past research in this area, as the results of this research are probably grossly understated. Also mentioned previously is the fact that large numbers of trips between the same two locations should be considered prime targets for video teleconference substitution. The list of prime substitution targets should also include trips which either involve long distances for short duration meetings or trips requiring large numbers of people to travel.

In addition to the factors just mentioned, a business manager must be aware of and sensitive to certain human and communication factors which bear on travel substitution. The following guidelines, condensed from a Bell Canada Report, briefly summarize these factors and their relationship on potential travel substitution.²⁹

1. As the complexity of the communication task increases, the greater is the perceived need for travel, especially where bargaining, conflict resolution, and authority relations come into play.
2. Personal familiarity is negatively related to the willingness to replace travel in situations which require building or maintaining friendly relations, persuasion, assessment of other's reactions, or security.
3. Routine actions have a lower trip threshold and a greater propensity for substitution.
4. The propensity to replace a trip varies with the purpose of the trip and increases after a certain threshold of trip making is reached.

5. Trips which involve the personal transportation of materials, or which require equipment service and handling, are not substitutable.
6. There is a negative relationship between the duration and number of activities engaged in on a business trip and the propensity to substitute.
7. There is a negative relationship between the number of non-business activities associated with the business trip and the propensity to substitute.
8. There is a negative relationship between how business travellers feel about their general travel activities and the willingness to substitute.
9. There is a negative relationship between an individual's position in the business hierarchy and the willingness to substitute, although this fact may be reduced if the time-savings factor of video teleconferencing is emphasized.
10. There is a positive relationship between the traveller's perception of the utility of telecommunication alternatives to business travel and the willingness to replace travel.

The guidelines listed in this section are certainly not all-inclusive; however, they do provide a starting point for the business manager in making substitution and substitutability estimates. In the end, these estimates will probably be made based upon "pure instinct" more than any other factor. Since the business manager is close to the travel situation, we feel that the pure instinct method will suffice for performing an analysis of the type described in this chapter.

Implications for Business and Government

Once a video teleconference system is placed into operation, what is now called a travel budget should be renamed a "conference budget". From this time on, the decision as to whether to satisfy a

particular conference requirement by travel or video teleconferencing should be made on a case by case basis. For the Picturephone Meeting Service option this is not difficult. For a privately-owned system, however, it is difficult and certainly not precise. In general, however, what we've said before bears repeating. If a trip involves traveling a long distance for a short duration meeting, or if a large number of people must travel, it is probably highly substitutable, from an economic point of view. Further, it should be pointed out, that the more a video teleconference system is used, the more cost effective it becomes.

In the course of the discussions above, it is natural to assume that replacing travel with video teleconferencing implies holding the same number of conference meetings at a lower overall cost. In practice, this may or may not be the case. Once a monetary savings is obtained from video teleconferencing, the business manager has the option of either,

1. Conducting the same number of conferences at a lower overall cost, or
2. Conducting more conference meetings at the same overall cost.

In either case, a cost-effective benefit is realized by the organization.

Conclusion

The methods, examples, and thoughts presented in this chapter are designed to aid the business and government manager in ascertaining the potential cost effectiveness of video teleconferencing

as a travel substitute within their organizations. Much of what we've said and done is original, and it therefore represents a step beyond (a giant step, we believe) past attempts in this area. It is hoped that our work might serve as a foundation for further research into the cost effectiveness of video teleconferencing as a substitute for business travel.

FOOTNOTES

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6. National Transportation Policy Study Commission, The Impact of Telecommunications, p. 16.
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CHAPTER VI

SOCIAL IMPACTS AND BENEFITS

Introduction

The purpose of this chapter is to outline the social benefits and impacts of video teleconferencing. Five basic areas of benefits and impacts will be addressed: the energy crisis, air pollution, medical applications, applications for education, and aid to the deaf. In reviewing these topics we will, for the most part, talk about potential benefits, to be realized in varying degrees as video teleconferencing gains wider and wider acceptance. In many cases we will talk about these benefits in terms of video teleconference systems of the future. The specifics of these future systems will be discussed in Chapter VII. The first topic to be addressed is perhaps the most important -- the potential role of video teleconferencing in resolving the energy crisis.

Video Teleconferencing and the Energy Crisis

We are currently in the midst of a very real energy crisis, a crisis which has resulted in economic chaos for oil importing countries all over the world. As mentioned in the previous chapter, the growing scarcity of fossil fuels, coupled with heavy increases in the demand for these resources and production cutbacks by oil exporting countries, have caused petroleum costs to soar. But high costs are only part of the problem. In the United States (and other countries

as well), the demand for crude oil far exceeds the supply which is available within the country. Thus, we have become increasingly dependent on more costly foreign oil sources.¹ Large purchases of crude oil from these foreign sources have been almost solely responsible for our growing imbalance of trade and rapid inflation. In the future, we can expect increases in unemployment and a slowing of economic growth, as further consequences of the energy situation.

The predicted impacts of the latest Organization of Petroleum Exporting Countries (OPEC) price increase on June 28, 1979, on the American economy will serve to illustrate the severity of the problem.²

- (1) Economic forecasters who several months ago were looking for inflation of around 8.5% this year are now predicting inflation of 10%.
- (2) At the start of this year, Merrill Lynch predicted that gasoline and motor fuel prices would increase 3.3% this year...now they are predicting at least a 40% price increase.
- (3) Administration officials predict that our country's economic growth rate will be slowed an additional 1% for the next two years as a result of the latest price increase.
- (4) As many as 800,000 additional jobs will be lost, and unemployment is expected to rise between 7.0 and 8.3% (the current rate is 5.6%).

Clearly, a quick and long-lasting resolution to our energy problems should be at the top of everyone's list of priorities.

There are two basic approaches to dealing with the energy crisis. The first approach is to search for new and more energy resources here in the United States. In this category are such actions as

increased petroleum exploration and solar and nuclear energy development and research. The second approach is a conservation approach. Included here are such things as proposed rationing of fuel, tax incentives to homeowners who install new energy-saving devices, domestic crude oil price deregulation, mandatory thermostat settings, tax surcharges, and telecommuting techniques.³ Both approaches theoretically reduce our dependence on imported oil, but the conservation approach has the added advantage of simultaneously reducing demand. Clearly, both approaches are necessary, but in order to achieve maximum long-term results, the conservation approach should be emphasized.

Researchers have been investigating the potential of telecommuting to conserve energy through travel substitution since the Oil Embargo of 1973-74. The results of these investigations are as follows.⁴ One study, which assumed that telecommuting would substitute for 20% of business air travel in the United States by the year 2000, predicted a 0.3 to 0.7% energy savings. The same source predicted further that substitution for intercity travel by automobile could cut energy use by an additional 0.5 to 1.0%.⁵ Another study predicted that a 3.0% reduction in petroleum consumption could result from substitution of telecommuting for automobile transportation between cities.⁶ Studies have also been made regarding the potential savings which could be derived from urban passenger (intracity) travel substitution. Based upon a projected 16% reduction of urban vehicle miles, one study placed potential energy savings at 7.0%.⁷ Another study examined energy used solely for commuting. Their findings predicted a 1.0% replacement of urban commuting by telecommuting would result in a net reduction in gasoline consumption of 5.36

million barrels annually.⁸ Finally, Lathey estimates that U.S. petroleum demand could be reduced 7% through a combination of urban and intercity telecommuting.⁹

In addition to the studies above, which dealt with the pure travel substitution effects of telecommuting, other studies have been conducted regarding the potential effect of urban work decentralization on energy consumption. The assumption here is that telecommuting (largely video and computer teleconferencing) could alter work, office, and business location patterns.¹⁰ More specifically, these systems could allow wide usage of neighborhood office centers or even work at home. The results of one of these studies were as follows:¹¹

- (1) If half of all office employees worked at neighborhood office centers, U.S. petroleum demand could be reduced by 1.2%.
- (2) If half of all office employees worked at home, the savings would be 1.5%.

As is obvious from the discussion above, research into the topic of telecommuting as an energy savings device is somewhat incomplete and largely inconclusive. Specific research into the area of video teleconferencing as an energy saver is simply non-existent, but it is reasonable to assume that results for these studies would be similar to those of telecommuting as a whole. Despite these inadequacies, results thus far are sufficient to justify the presumption that video teleconferencing has a tremendous potential to cut energy demands, and thus ease the energy crisis.

Air Pollution

Air pollution is still another problem which stems from the

consumption of fossil fuel energy resources. This pollution is of two basic types: carbon by-product poisoning and thermal pollution. The harmful effects of carbon poisoning in the air have been demonstrated on many occasions and high carbon concentrations in the atmosphere have been linked to several major illnesses, such as emphysema, bronchitis, asthma, and lung cancer.¹² The so-called "brown cloud" which now hovers over many of our major cities is a constant reminder of the presence of high concentrations of carbon in our air. Somewhat less obvious and less known are the effects of thermal pollution. The laws of thermodynamics dictate that all energy used by man must ultimately be dissipated as heat. In the case of fossil fuels, or any other source other than incident solar energy, this heat will gradually warm the atmosphere. Atmospheric waste heat causes the formation of heat islands around cities, within which many meteorological anomalies occur. In addition, thermal pollution is known to have serious worldwide climatic consequences.¹³

Air pollution, whether it be thermal or carbon, is a very serious problem. In fact, the authors of the classic book, The Limits to Growth, believe that air pollution, left uncontrolled, could help to bring about the end of the world before the year 2100,¹⁴ and they consider pollution to be one of the four critical factors affecting the longevity of life on earth.¹⁵ Their book details the results of several computer simulations which predict the course of the world's future. In their original computer run, life ceases to exist at about the year 2050, largely because nonrenewable resources have been completely exhausted. When these resources are considered to be unlimited, a second computer run predicts the end of the world

in about the year 2090; this time pollution (largely air pollution) is the determining factor.¹⁶

Today, seven years after The Limits to Growth was published, air pollution appears to be headed in the direction the study predicted. Air pollution is worsening daily, at an exponential rate, and it is no longer confined strictly to major metropolitan areas and heavy industrial centers. One recent source said this:

New scientific finds disclose that the nation's air is getting dirtier, with a pollution-created haze affecting visibility across the nation, including the once-pristine air of the desert Southwest.¹⁷

The same source goes on to state that a significant amount of air pollution is now present "in remote unpopulated areas as well as rural and suburban locations and smaller cities."¹⁸

Are we, then, headed for doom? Perhaps not. The authors of The Limits to Growth emphasize repeatedly that their models are not deterministic and that many things can be done to extend or remove the limits they predict. One of the factors in which the authors place a great deal of faith is technology. This is where video teleconferencing comes into play.

The potential of video teleconference systems to substitute for travel has already been discussed. Previously, however, we were concerned primarily with the intercity substitution potential. From the standpoint of air pollution, the main benefits will come from urban travel substitution. Several studies have been done to estimate this potential. In the United States, the results range from a 14 to 47 substitution potential depending upon the location, the method of prediction, and the time in question.¹⁹ Further, it has

been estimated that

for each one percent reduction in urban automobile traffic brought about by conversion to video teleconferencing, a reduction in urban air pollution of approximately 0.8 percent would result.²⁰

This reduction may be even greater due to reductions in commuting congestion. Based upon the 0.8 percent estimate alone, however, a 14% reduction in interurban travel would result in a corresponding reduction in urban air pollution of 11.20%, while a 47% reduction in travel would bring about a 37.60% reduction in air pollution. Clearly, the technology of video teleconferencing has the potential to vastly alter the possible catastrophic effects of air pollution in future years.

Medical Applications

Video teleconferencing also has the potential to benefit the medical community, and as a result, society as a whole. Although most Americans have ready access to adequate medical facilities and qualified medical personnel, there is still room for improvement. This is especially the case in the areas of rural medical treatment, continuing medical education, hospital costs, more effective use of allied medical personnel, and consultation services. In 1972, William B. Schwartz summarized the prevalent medical problems of his time. What he said then is still very true today. His remarks were as follow:

The problem of delivery of primary medical care obviously has an enormous number of facets. It

is not merely a question of more medical schools training more physicians, but a range of issues including the maldistribution of physicians, inducements to rural and ghetto practice, restriction on the entry of physicians into specialties already overpopulated, the use of allied medical personnel to replace physicians in the delivery of primary care, the introduction of computer-aided diagnosis and management as a means of upgrading the non-physician's performance, the use of television as link between doctors and patients, and the introduction of new transportation strategies as a means of making high-quality care available to areas of low population.²¹

As mentioned in Chapter II, video teleconferencing is already being used to help resolve these and other medical problems. Where medical video teleconference systems have been used they have facilitated remote consultations, remote supervision of allied medical personnel (such as paramedics, nurses, etc.) by physicians, and remote telediagnosis. In addition, they have provided access to computerized medical records, automated medical information systems, and improved the timeliness and quality of continuing medical education.²²

There are twelve medical video teleconference systems known to be in use today (see Table I). Of these, the Massachusetts General Hospital (MGH)-Veteran's Administration (VA) Hospital CCTV system is perhaps the best known. This system, which has been used primarily to perform remote medical examinations (including psychiatric, ocular, and dermatological examinations) provides a transmission quality better than broadcast television.²³ In addition to the link to the VA Hospital, MGH uses a similar two-way CCTV system to provide telediagnosis to a medical station at Logan Airport in Boston. Because of the link, the station can now be manned strictly with nurse practitioners who receive remote assistance from physicians at MGH.^{24,25}

Other medical video teleconference networks have also been placed into operation. The Vermont-New Hampshire Medical Network, for instance, uses microwave links to provide medical conferencing, remote consultation, and remote speech therapy services between the two facilities. The Mt. Sinai Hospital video teleconference system in New York City boasts that "nurses can now handle 60% of patient cases as opposed to 25-30% before teleconsultation capability."²⁶ A system at the University of Alabama School of Dentistry provides dental surgery training. The New York City Health Services Administration system is used to provide telemedicine services to and from neighborhood pediatric centers. A U.S. Navy system called MEDINAV aims to reduce rising medical costs, provide services in isolated areas, and compensate for a shortage of trained physicians. The Los Angeles Medical TV Network and the Network for Continuing Medical Education (New York) provide continuing medical education on a state-wide basis, and the Georgia Regional Medical TV Network provides the same service in the Atlanta, Georgia area, only. The Alaska Medical Satellite Network provides remote diagnosis, consultation, and treatment to many small Eskimo and Alaskan Indian villages in remote areas of the state from qualified medical personnel in Anchorage and Fairbanks. Finally, the Nebraska Psychiatric Institute at Omaha and the Norfolk State Medical Hospital have used video teleconferencing since 1964 for staff education and remote consultation.²⁷

The services provided by the systems just discussed have changed the medical profession in many ways. The following is a list of some of the impacts which these systems have had on the medical communities they serve.²⁸

- (1) Expansion of the capabilities and responsibilities of paramedical personnel.
- (2) Improved medical care in rural areas and urban ghettos.
- (3) Alteration of the social structure of the health care community.
- (4) Increased efficiency in the use of hospital facilities.
- (5) Alteration of the doctor-patient relationship.
- (6) Improved and more timely continuing medical education.

Although not specifically stated in the list above, one of the most beneficial impacts of medical video teleconference systems, both today and in the future, is a reduction in medical costs. The systems described thus far reduce effective medical costs to some degree by allowing paramedics and other personnel to substitute for physicians, and by reducing the amount of travel required to receive treatment (in the case of rural and isolated areas). However, the most significant reductions in medical costs will come in the future when home video terminals are commonplace. The National Research Council has done some research into the feasibility of using interactive home video terminals for medical treatment, diagnosis, and consultation. The results of their work are summarized as follows:

The average American makes between 4 and 5 visits a year to a health care provider -- about one billion outpatient visits per year. Home (video) terminals and equipment might play a role in half of these visits and perhaps deal with half of these again without requiring the patient to visit the provider....this might result in saving one visit per year per capita. This figure might be higher for the elderly and very young children, both of whom have visit rates much higher than the average.²⁹

The National Research Council report goes on to cite a specific example in which a patient with an uncomplicated myocardial infarction could be treated remotely using video teleconferencing at a cost of \$1600, whereas hospitalization would have cost \$3150,³⁰ a savings of almost half. Clearly, the potential for large medical cost reductions is there.

The paragraphs above have summarized the major impacts of and applications for video teleconferencing in the medical community. It is encouraging to note that the medical community has been quick to adopt and use video teleconferencing. As evidence of this fact, almost half of the video teleconference systems in use today are medical systems. As these medical systems gain prominence in the years to come, we can expect nothing short of improved medical services at lower costs.

Applications for Education

We seem to be on the threshold of a learning society in which learning is regarded as essential, not only for the survival of man, but also as a route to social and individual maturation, the key to personal development, and adaptation to social changes...³¹

In 1974 alone, there were 100 to 120 million people enrolled in learning programs in the United States.³² Since that time the number has swollen even more. Additionally, it appears that part-time learners in all types of post-secondary and independent study will continue to increase. Video teleconferencing has the capability to help our learning institutions cope with this massive quest for knowledge.

The primary benefit to be derived from educational video teleconference systems is a reduction in travel, both student and

teacher travel. This travel can be reduced in two ways. First, students in outlying areas can receive classroom instruction at remote classroom studios from teachers located on-campus. In this case, students usually travel less because remote studios are local, while teachers do not travel at all. Secondly, guest lecturers can visit campuses via video teleconference systems. In this case neither teachers or students are required to travel.

A secondary benefit to be derived from these systems is a reduction in facility and staff expansion. Greater demand for learning, if satisfied on campus, would ultimately require an expansion of classroom facilities and faculty. Most universities and large educational institutions have already solved half of this problem by establishing remote learning centers in outlying and suburban areas. Without video teleconferencing, however, these centers generally dictate an increase in staff and faculty, if for no other reason, because of the amount of time required for instructors to commute to and from the main campus. However, remote learning centers, which are usually leased at lower suburban rates, offer an attractive alternative to facility expansion on the main campus. Video teleconferencing can help to combine the facility cost advantages of remote classroom instruction, while at the same time eliminating the distasteful requirement for instructor travel. Thus, as enrollments grow, remote video teleconference studios, not new, on-campus construction, can be used to satisfy the demand.

Hundreds of experiments have been conducted on the feasibility of using video teleconference systems for remote education. The results of these experiments have been extremely favorable and the

indications are that education via the teleconference mode would be well accepted by the learning public. One survey conducted at the University of Wisconsin yielded the following results:³³

- (1) 23 percent of all adults are interested in non-degree continuing education.
- (2) 27 percent of all adults are interested in education leading to a degree.
- (3) 64 percent of these adults (in 1 & 2 above) think that they could complete more education if video teleconference systems were available.
- (4) 80 percent think that video teleconferencing would improve access to education.

Although teachers who have used these systems sometimes experienced initial difficulty adapting to the video teleconference mode of instruction, most agreed that the systems offered great potential for improved and expanded educational services.³⁴

As mentioned in Chapter II, there are educational video teleconference systems known to be in use today. Most of these systems have been in operation for a number of years. The longevity and accomplishments of some of them are worthy of note. The Hagerstrom, Maryland system, for example, has been in operation since 1956. It provides instruction in specialized science courses which would otherwise not be available due to lack of staff. The Indiana University system, which has been in existence since 1967, offers undergraduate and graduate courses and continuing professional education to several locations in outlying areas. Finally, the University of Florida system, GENESYS, operational for ten years, had awarded over 200 advanced degrees as of 1976.³⁵

As with medical systems, the full potential of educational video teleconferencing to aid society will probably not be realized until the home video terminal becomes a reality. Until then, the successes of current systems, combined with the ever-increasing demand for learning, will most likely stimulate the further growth of educational video teleconferencing in its present form.

Video Teleconferencing and the Deaf

There are more than 38,000,000 deaf people in the United States today.³⁶ For these people, communication of all types is awkward, difficult, and oftentimes impossible. Among themselves, the deaf communicate almost entirely by standard manual sign language. Since most hearing people do not know sign language, however, the predominant mode of communication between the deaf and the hearing is the written message (however, a third party is sometimes used as an interpreter). Although many people believe that most deaf people can read lips, the fact is that very few can. This serves to further complicate face to face communication outside the deaf community.³⁷

Conventional telecommunication systems have done little to assist the deaf in their communication battle. The conventional telephone, for example, which most people rely upon heavily, is useless to the deaf. Consequently, "a deaf person often walks short distances to deliver a trivial written message which the hearing would deliver by telephone,"³⁸ and long distance communication is virtually impossible. Keyboard and facsimile systems have been used by the deaf on occasion, but they proved to be cumbersome and awkward to use and too uncommon to be of benefit.³⁹

The inability of the deaf to use conventional telecommunications has resulted in numerous social problems and inadequacies. Employment opportunities and advancements have been limited, at least in part, because of the deaf's inability to effectively use the telephone. Deaf people have traditionally taken jobs at the bottom of the employment ladder, where little non-written communication is required. Socially, the deaf have congregated in "deaf communities" within cities, so that they can remain within walking distance of other deaf people, the only people with whom they can communicate comfortably.⁵⁰

Although the video teleconference system of today (see Chapter II) does not appear to have the potential for resolving deaf communication problems, the video telephone and the future home video terminal do. The added dimension of these devices combined with their random access capability make them well-suited for use by the deaf community. In addition, widespread use of these devices could help to alter the adverse social and employment trends discussed above. One author called the video telephone "the first telecommunications device well-suited for use by deaf people."⁴¹ Another author said that "for the deaf, the video telephone could mean new social interactions that hearing people take for advantage."⁴²

During the Picturephone era, tests using the Stromberg-Carlson Vistaphone proved the video telephone's ability to aid communications between the deaf. These tests, which were conducted at the National Technical Institute for the Deaf in Rochester, New York, caused great excitement within the deaf community. Finally, they thought, there was a telecommunications device which could be to them what

the telephone had been to the hearing. Finally, it was predicted, the deaf would be able to communicate with the hearing in the business world, and employment barriers would be eased.

As we all know, the video telephone was not to become commonplace in the home and business office. Consequently, the potential of video teleconferencing to aid the deaf has not yet been realized. However, the deaf are well aware of the video telephone and its capability to enrich their lives. If and when video telephones reappear, then, it is likely that the deaf will stretch their personal finances to equip their homes with them far earlier than other people.^{43,44} In fact, it is reasonable to assume that the deaf may be the first (even before business) to adopt a new video telephone. Further, it is not entirely inconceivable that someone might develop a new video telephone, specifically designed to serve the deaf community. In any case, home video terminals will provide partial solutions to the problems of the deaf in the near future. If and when these events come about, a whole new world, the world of telecommunicating, will be opened to the deaf.

Conclusion

This chapter has briefly described five major areas where video teleconferencing can be expected to have significant social impacts. There are certainly other areas, not discussed here, where social impacts can be envisioned. Things such as reductions in noise pollution and traffic congestion, and use of land and capital resources for other than highway and road construction are examples. The major benefits, however, will come from the five included in this chapter.

We caution, though, that some of these benefits, particularly telecommunications for the deaf, will not come until video teleconferencing gains wide acceptance in the home and office. The final chapter of this paper will make some predictions as to when this wide acceptance will come about.

FOOTNOTES

1. In 1970, for example, the United States imported 23.3% of its oil needs at a cost of 2.9 billion dollars; in 1976, the U.S. imported 42.0% of its needs at a cost of 34.6 billion dollars. (Source, Energy in Focus: Basic Data, U.S. Dept. of Energy, 1976).
2. "Latest Oil Bite Touches All," p. 9.
3. The basic category "telecommuting" includes, among other things, audio, video, computer, and facsimile teleconferencing in lieu of travel.
4. Although investigations have been conducted in several oil-importing countries, only the results of U.S. studies will be discussed here.
5. National Transportation Policy Study Commission, The Impact of Telecommunications, pp. 30-31.
6. U.S. Department of Commerce, Telecommunications Substitutability for Travel, p. 48.
7. P. Polishuk, "Review of the Impact of Telecommunications Substitutes for Travel," IEEE Transactions on Communications, vol. COM-23, no. 10, October 1975, pp. 1089-1098.
8. National Transportation Policy Study Commission, The Impact of Telecommunications, p. 31.
9. U.S. Department of Commerce, The Contribution of Telecommunications to the Conservation of Energy Resources, p. 27.
10. Dickson and Bowers, The Video Telephone, pp. 114-123.
11. National Transportation Policy Study Commission, The Impact of Telecommunications, p. 33.
12. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers and William W. Behrens, III, The Limits to Growth, (New York: New American Library, 1972), p. 125.
13. Ibid., p. 85.
14. Ibid., p. 132.
15. Food, population, and nonrenewable resources are the other three critical factors listed by the authors.
16. Meadows, Meadows, Randers, and Behrens, The Limits to Growth, p. 139.
17. "U.S. Air Quality Worsens," The Denver Post, June 9, 1979, p. 1.

18. Ibid.
19. National Transportation Policy Study Commission, The Impact of Telecommunications, pp. 21-23.
20. Ibid., p. 38.
21. William B. Schwartz, "Policy Analysis and Health Care Systems," Science, September 15, 1972, p. 967.
22. Dickson and Bowers, The Video Telephone, p. 156.
23. The horizontal resolution in the MGH system is about 800 pels/line, compared to about 640 pels/line in broadcast television.
24. Dickson and Bowers, The Video Telephone, p. 158.
25. U.S. Department of Commerce, Lowering Barriers to Telecommunications Growth, p. D-3.
26. Ibid.
27. Ibid., pp. D-3, D-4.
28. Dickson and Bowers, The Video Telephone, p. 163.
29. Telecommunications for Metropolitan Areas: Opportunities for the 1980's, National Research Council Report No. NRC/TELECOM/78-1, National Academy of Sciences (Washington, D.C.: 1978), p. 23.
30. Ibid., p. 24.
31. Ibid., p. 15.
32. Ibid., p. 17.
33. Ibid., p. 18.
34. Ibid., pp. 16-17.
35. U.S. Department of Commerce, Lowering Barriers to Telecommunications Growth, pp. D-3, D-4.
36. "Picturephones and Beyond," p. 46.
37. Dickson and Bowers, The Video Telephone, p. 49.
38. Ibid., p. 150.
39. "Picturephones and Beyond," p. 46.
40. Dickson and Bowers, The Video Telephone, p. 149.
41. Ibid., p. 148.

42. "Picturephones and Beyond," p. 46.
43. Ibid.
44. Dickson and Bowers, The Video Telephone, p. 151.

CHAPTER VII

CONCLUSION

In the previous chapters we have discussed the evolution of video teleconferencing, some of the technological, human, and social factors which bear on video teleconference system usage, and the potential for video teleconferencing to substitute for travel. The question remains, however, as to what the future holds for video teleconferencing.

It is obvious that video teleconferencing is not, at present, a widespread activity even though video teleconference systems of various types have been in existence for several years. Before attempting to forecast the future of video teleconferencing it may be helpful to recount some of the barriers which have hindered its growth.

Video Teleconferencing Barriers

In general terms the barriers to video teleconferencing can be labeled technological, economic, and human. Specifically, some of the most important barriers have been:

- (1) The cost of video equipment and transmission links.
- (2) The limited capacity of the existing communications network to provide broad bandwidth, switchable, video paths.
- (3) An abundance of cheap energy for travel.

- (4) The reluctance of people to break existing travel habits and accept new methods.
- (5) The inhibiting effects of the highly publicized failure of Picturephone on potential manufacturers and users of this type of system.
- (6) The fact that at the present time no single vendor is offering a "package" video teleconference system on the market.

Perhaps the most detrimental of the barriers to video teleconferencing have been those concerning technology and economics. At the present time, however, the trends in these two areas seem to be moving in directions which will favor the development of video teleconference systems. As noted in Chapter III, technological developments are resulting in transmission systems of ever increasing capacities. Simultaneous developments are reducing the capacity requirements for transmission of video signals. Furthermore, the costs of video equipment and transmission links have been steadily decreasing as have the costs of most electronic devices. Figure 6 demonstrates the present and projected downward trend in transmission costs. Chapters V and VI detailed the rapid increase in energy costs as well as the importance of conserving our rapidly depleting energy sources. Based on present technology capabilities, transmission and equipment costs, and energy costs, video teleconferencing is now a viable economic travel alternative in some circumstances. It appears, given the trends mentioned above, that the number of circumstances favorable to video teleconferencing will continue to expand.

As economic pressures for usage of video teleconferencing increase and more systems are installed, the human barriers to usage will tend

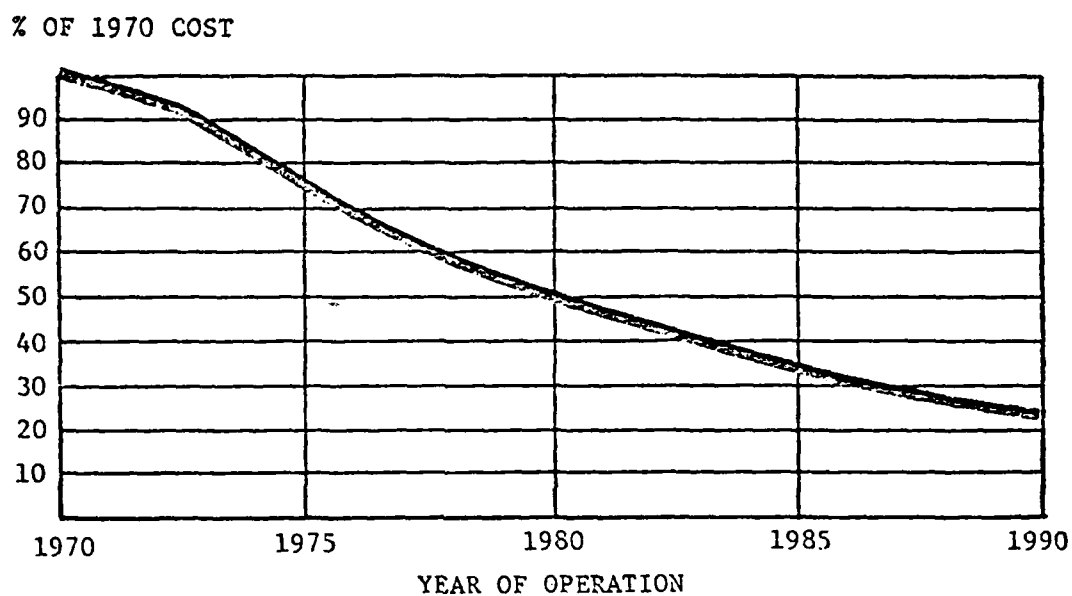


Figure 6. Trend in Transmission Cost Per Unit of Capacity, 1970-1990.
(Source: National Transportation Policy Study Commission,
The Impact of Telecommunications on Transportation Demand
Through the Year 2000.)

to decrease. The resistance of people to accept new methods is greatly reduced if they are able to observe successful applications of these methods -- particularly if the new methods are less costly. Further, observers will quickly forget the failure of past video teleconference systems, such as Picturephone, when they see successful systems operate. This, in turn, will stimulate manufacturers of video teleconference systems which should have the effect of reducing costs due to increasing competition.

In short, many of the barriers which have inhibited video teleconferencing in the past are now becoming positive factors which will increase the usage of video teleconferencing in the future. The next section will consider another potentially positive influence on video teleconference systems.

The Role of Government

The purpose here is neither to advocate nor oppose government intervention in the area of video teleconferencing. It is a fact, however, that the Federal government is already deeply involved in the regulation of the entire telecommunications industry. The government is also very concerned about such topics as energy, inflation, unemployment, and the economy. In view of the social benefits which potentially can be derived from conserving energy through the use of video teleconferencing, it is not unreasonable to assume that a governmental role will be developed. The importance of energy resources was dramatically emphasized, during the writing of this paper, by a Presidential proposal to spend billions of dollars to develop new sources of energy for our nation. Similar importance is attached to

energy conservation and there are a number of ways the government can encourage video teleconferencing and its resulting energy savings.

One type of government role would be to set an example for private enterprise to follow. Both NASA and GSA now have successful teleconferencing systems in operation. By implementing widespread video teleconference systems in the Department of Defense, Department of Commerce, HEW, and other Federal agencies and reducing travel in these agencies, others might be encouraged to develop and use similar systems. A second governmental alternative involves providing a special tax advantage to those saving energy through the use of video teleconferencing. Similar methods are presently in use to aid homeowners improving the energy efficiency of their houses. A third role for government would be to provide funds for the further development and usage of video teleconference systems just as funds are provided to search for and develop new energy sources. One particular facet of this latter role is sponsoring and publishing studies of video teleconferencing, especially in view of the dearth of current information on the subject now available from governmental sources.

There are doubtlessly many other ways the Federal government could become involved in the future of video teleconferencing. It appears very likely that at least one or more of these methods will be used to further the usage of video teleconference systems.

The Video Teleconference System of the Future

Based on the technological and economic trends previously discussed, along with the strong possibility of positive governmental influences, the growth of video teleconferencing beyond its present

status seems certain. Therefore it is appropriate to discuss the configurations video teleconference systems can be expected to assume in the future.

Within the next five to ten years, video teleconference systems are expected to transition slowly from predominantly black and white, small systems into elaborate full color, full-feature systems. The new systems will primarily be studio-based, have large screens, video and audio recording capability, user operated voice activated cameras, high quality graphics modes provided initially by telefacsimile and later by high resolution cameras, and they will continue to be operated primarily from point to point. Towards the end of this period mobile video teleconference systems with built-in satellite earth stations will begin to be discussed for medical, educational, and other uses in remote areas.

In the period ten to twenty years in the future, additional features will become available for use with video teleconference systems. Many of these features will result from the synthesis of video and computer based teleconference systems into what may be called information processing terminals. These terminals will have keyboard entry capability and the ability to produce hard copies of video images as well as textual material. They will also have optical character reading capability, the ability to access large data storage banks, and adequate software to assure compatibility between systems. As the use of optical fibers becomes more widespread, video teleconferencing will increasingly become a point to multipoint activity. Additionally, continuous improvements will be made in the human engineering of these systems so they will become increasingly "user

transparent". The average user will no longer need to know or care any more about the details of the hardware or software of the system than today's average user of the telephone knows or cares about its operation. Many other features not yet envisioned will be developed and integrated into video teleconference systems as users become progressively more sophisticated, knowledgeable, and demanding of new capabilities.

Projections for Future Use

Now, after this brief review of the expected design and growth influencing factors of video teleconference systems, we return to the original question. What does the future hold for video teleconferencing?

The authors feel that the primary impetus for near term video teleconferencing growth will come from large corporate and governmental organizations. The purpose of most of the video teleconference systems placed in use during the next five years will be to reduce travel costs and energy consumption through travel substitution. These systems will primarily use satellite transmission links and many of the users will be among the target group of customers who are planning to use the services offered by Satellite Business Systems. During the next ten to fifteen years, the continued reductions in transmission link costs and the increases in optical fiber usage will attract many more participants to video teleconferencing. In this period many smaller businesses, state and local governments, educational institutions, and hospitals will implement video teleconference systems. During the latter part of this century, the information processing terminals previously mentioned will be found in almost all business and public

institutions and in many homes. The widespread proliferation of optical fibers will allow subscribers to employ terminals for many uses. Among these are cashless transactions, electronic newspapers, computer-aided instruction, consumer advisory services, electronic meetings, remote library access, home based job performance, and many others. Obviously many of the functions envisioned for future usage of video teleconference systems will have a large impact on our society as we know it today.

While it is important to attempt to visualize the consequences of the growth of any rising technology, sometimes the future predictions can be so utopian that the present capabilities seem disappointingly unimpressive. It appears that video teleconferencing may have been a victim of this type of situation in the past. We think, therefore, that it is important to reiterate that video teleconferencing has already proven itself to be a viable economic alternative to travel in some circumstances. We feel that those selecting video teleconference systems should only evaluate them on their present effectiveness and economic viability and not rely too heavily on optimistic forecasts of future capabilities of these systems. We are confident that if the day-to-day value of video teleconferencing is judged in this manner, the future performance of video teleconferencing will be assured of meeting the optimistic predictions heard so often today.

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APPENDIX

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APPENDIX A

Bare-Bones Video Teleconference System

Description

A simple, black and white, CCTV system which will accommodate up to three primary conferees. A single camera is focused on all three at the same time. Another camera, directly above the conference table, is used for written documents and graphics. All equipment is off-the-shelf and inexpensive. Transmission is via satellite. A suitable corporate conference room is assumed to already be in existence.

System Costs (July 1979)Equipment (each end)*

Conference camera.	\$ 350.00
Graphics camera.	350.00
Receive monitor.	200.00
Transmit monitor.	200.00
Microphones (3 @ \$20 each)	60.00

Total each end \$ 1,160.00

Total equipment costs (both ends). \$ 2,320.00

Transmission Link**

Satellite time	\$36,000.00/year
Local loop and termination charges	12,000.00/year

Total. \$48,000.00/year

Installation and Wiring Charges* \$ 232.00

Maintenance* (first year free) \$ 234.00/year

* Obtained by telephone from commercial video equipment vendors in the Denver, Colorado metropolitan area.

** Obtained by telephone from Western Tele-Communications, Inc. Satellite cost is based upon a long-term lease contract for four hours usage per week during morning hours, at a cost of \$180/hour.

APPENDIX B

Full-Feature Video Teleconference System

Description

An elaborate system including features such as full animated color, large screen projection, video cassette recording, and voice activated cameras. The system can accommodate up to six primary conferees. Five cameras are used. Three voice activated cameras are focused on two conference participants each. A fourth overview camera permits viewing the entire conference area at once. The fifth camera is used for text and graphics. All equipment is available off-the-shelf, at a nominal cost. Transmission is via satellite. A suitable corporate conference room is assumed to already be in existence.

System Costs (July 1979)Equipment (each end)*

Conference cameras (3 @ \$1400)	\$ 4,200
Graphics camera	1,400
Overview camera	1,400
Control panel (table top)	200
Voice activation.	300
Lapel microphones (6 @ \$30)	180
72" projection screen	3,995
Transmit monitor.	500
Speakers (2 @ \$100)	200
Audio amplifier	250
Video cassette recorder	1,200
Total each end	\$13,825
Total equipment costs (both ends)	\$27,650

Transmission Link**

Satellite time.	\$54,000/year
Local loop and termination charges.	12,000/year
Total	\$66,000/year

Installation and wiring* \$ 2,765

Maintenance (first year free; thereafter) \$ 2,737

* Obtained by telephone from commercial video equipment vendors in the Denver, Colorado metropolitan area.

** Obtained by telephone from Western Tele-Communications, Inc. Satellite cost is based upon a long-term lease contract for six hours usage per week, during morning hours at a cost of \$180/hour.