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VIDEO TELECONFERENCING
FEASIBILITY STUDY AT THE
NAVAL POSTGRADUATE SCHOOL

by

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A preliminary study was completed that measured the operational and technical feasibility of video teleconferencing (VTC) at the Naval Postgraduate School (NPS). As part of the fact-finding effort, a VTC Round Table was convened in order to define the nature of the problems that prompted NPS to consider VTC as a possible solution. Potential opportunities for utilizing VTC to improve the quality of education offered by NPS were discussed, and various alternatives for installing a system were considered. It was concluded that the operational and technical feasibility of VTC were convincing enough to justify the continuation of VTC implementation at NPS. The economic aspects of VTC were viewed to be of secondary importance because case studies indicate that the quantitative benefits such as travel displacement have been overshadowed by the

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VIDEO TELECONFERENCING FEASIBILITY STUDY AT THE NAVAL POSTGRADUATE SCHOOL

by

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of the requirements for the degree of

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ABSTRACT

A preliminary study was completed that measured the operational and technical feasibility of video teleconferencing (VTC) at the Naval Postgraduate School (NPS).

As a part of the fact-finding effort, a VTC Round Table was convened in order to define the nature of the problems that prompted NPS to consider VTC as a possible solution. Potential opportunities for utilizing VTC to improve the quality of education offered by NPS were discussed, and various alternatives for installing a system were considered. It was concluded that the operational and technical feasibility of VTC were convincing enough to justify the continuation of VTC implementation at NPS. The economic aspects of VTC were viewed to be of secondary importance because case studies indicate that the quantitative benefits such as travel displacement have been overshadowed by the qualitative gains such as increased productivity.

This study recommends that NPS move ahead with its plans to implement a "full-feature" VTC system and install it in a new academic building currently under construction. Additionally, this study acknowledges the findings of the draft DOD instruction, *Teleconferencing Activities, Systems and Networks*, which endorses the use of the Federal Telecommunications System (FTS)2000 for long-haul network services. It is recommended that NPS utilize the FTS2000 Compressed Video Teleconferencing Service (CVTS) for its VTC needs, and lease the VTC equipment with an option to buy.

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I. INTRODUCTION

In today's rapidly changing, "high-tech" business environment, more and more professionals are attempting to reduce the number of missed opportunities that occur when their organization fails to conduct more business at dispersed locations. At the same time, many organizations are aiming to find an affordable alternative to business travel as the sole means of conducting business at dispersed locations. As a result, video teleconferencing (VTC)[1] is being introduced into the office environment at an accelerating pace. In the past, VTC has been an expensive venture due to the high costs of the hardware and software development for VTC system components, plus the expensive nature of the higher bandwidth requirements for VTC transmission. However, there have been recent technological breakthroughs that have lowered the developmental and operational costs of VTC. The slow growth phase of VTC development has passed, and as a result, VTC will become a standard communications tool for large organizations that are geographically dispersed.

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[1] VTC will be explicitly utilized throughout this text to refer to the term *video teleconferencing*; however it is sometimes used to refer the term *videoconferencing* as well.

A. PURPOSE

If senior military officials are going to be asked to dedicate resources for VTC system acquisition, some form of justification must first be provided to convince them that VTC is more than just a good idea. In short, senior military officials must be convinced that VTC is feasible in terms of its operation, technology, and cost. With this in mind, the primary purpose of this study will be to determine if VTC is feasible at the Naval Postgraduate School (NPS).

B. BASIS OF THE STUDY

Prior to August 1990, the concept of implementing VTC at NPS had only been discussed informally. However, by the end August 1990, several factors changed the situation. With the announcement of decreasing *defense* dollars (D^3) by Congress, the advent of the Persian Gulf crisis (Operation Desert Shield/Desert Storm), and the dramatic increases in fuel prices and travel costs, the relevant importance of VTC at NPS increased considerably. Also, the surging popularity of VTC in the private sector and the recent attention that VTC had received in the media continued to elevate the awareness of VTC.

With this in mind, various groups within the NPS organization began to indicate an interest in exploring the advantages of establishing a VTC capability at NPS. The Director of Students and Programs (Code 03) and the Dean of

Information and Computer Services (Code 05) were among the most prominent.

Consequently, a need for further assessment as to the feasibility of procuring a VTC system had unfolded. This need serves as the basis for this study.

C. OBJECTIVES

The overall objective of this study is to provide the leaders at NPS with sufficient details concerning VTC in an attempt to establish whether or not the implementation of VTC is feasible. In doing so, this study will evaluate VTC to ascertain whether or not VTC can solve the problems that hinder the productivity of administrators, enhance the classroom environment and research endeavors of faculty and students, and reduce some of the costs that are associated with the daily conduct of business.

D. SCOPE OF THE VIDEO TELECONFERENCING (VTC) FEASIBILITY STUDY AT THE NAVAL POSTGRADUATE SCHOOL (NPS)

A VTC feasibility study is an excellent method for identifying the essential details concerning VTC implementation and can possibly serve as the catalyst for a final decision on VTC system acquisition. A thorough VTC feasibility study should state the urgency of the problems that prompted the leaders at NPS to consider VTC in the first place and carefully measure how beneficial the development of a VTC system would be to NPS. At the same time, it should also test for these two categories of feasibility:

1. Operational feasibility (how well the VTC solution will work in the organization).

2. Technical feasibility (the practicality of a specific technical solution and the availability of technical resources). [Ref. 1]

E. VTC FEASIBILITY STUDY ORGANIZATION

Following the introduction to the VTC feasibility study, a chapter that describes the background and recent developments in VTC is presented. This chapter provides a working definition of VTC systems and includes a brief history of VTC. It covers the events that guided the development of present-day VTC systems. It also includes a description of the future developments in telecommunications services and video coder-decoders (CODECs). The chapter concludes with a report on current VTC users and their comments on the VTC industry.

In Chapter III, the tools and techniques that were used to gather data for the VTC feasibility study are presented. This chapter carefully details the fact gathering strategy that started with the sampling of existing documents, forms, files, and other low-user contact methods; and culminated with a group work session that clarified the most troubling facts and issues.

The fourth chapter determines whether or not the procurement of a VTC system at NPS is feasible. This chapter presents its findings in terms of the operational and technical feasibility of VTC system implementation at NPS.

Finally, Chapter V recommends and delineates follow-on actions to the feasibility study. This includes a description of the three phases of the VTC implementation process that are natural extensions of the VTC feasibility study: research and design (R&D), procurement and implementation, and operations. The chapter concludes by providing a description of related topics that are suitable for further research.

II. BACKGROUND AND RECENT DEVELOPMENTS IN VTC

A. VTC DEFINITION

A working draft of an upcoming Department of Defense (DOD) directive on teleconferencing is titled: *Teleconferencing Activities, Systems and Networks.* This draft defines VTC as:

> The use of telecommunications systems to communicate with two or more locations in real time using audio and video or audio and graphics. The configuration can be point-to-point or multi-point. [Ref. 2]

When the subject of VTC is mentioned, what is ultimately implied is two-way (full duplex), interactive teleconferencing that employs the following "full-feature" characteristics:

1. Full-motion, digital video that employs data compression.
2. Digital audio that is time-delayed to synchronize with the video.
3. Digital graphics imaging.
4. Telewriting and data transfer.
5. Video cassette recording. [Ref. 3]

B. A BRIEF HISTORY OF VTC

The history of VTC traces its crude beginnings back to April 7, 1926, when Secretary of Commerce, Herbert Hoover, spoke on a VTC system with Walter S. Gifford, President of American Telephone and Telegraph (AT&T). Throughout the intervening years (1926 - 1964), Bell Laboratories (AT&T's

research subsidiary) continued to make improvements on this VTC system. By 1969, the Picturephone (the name under which it was marketed) was operationally tested and proclaimed a success by the manufacturers at Western Electric (AT&T's manufacturing subsidiary). However, the Picturephone's exorbitant price tag discouraged public interest when it was first offered in 1970. The Picturephone was finally scrapped by AT&T in 1971.

Shortly after the demise of the Picturephone, the United States became locked in the middle of an energy crisis that was initiated by the Organization of Petroleum Exporting Countries (OPEC) oil embargo of 1973. Soaring oil prices and "run-away" inflation forced the business sector to search for less expensive alternatives to traveling.

The telefacsimile (FAX) system emerged on the scene in 1974 and was initially the preferred method of teleconferencing. FAX systems operate in much the same way that a television (TV) camera scans an image (see Appendix A). A FAX system optically scans an image on a piece of paper and converts the image into an electrical signal for transmission over telephone or data lines. FAX systems (in tandem with telephones) continued as the most preferred method of teleconferencing until a second energy crisis in 1980 fueled further research in the area of teleconferencing (particularly VTC). This factor, along with further improvements in VTC, led to the development of digital video compression techniques, improved local and long-distance transmission services, and other improvements that have made "full feature" VTC a present reality.

1. Video Compression

Appendix A serves as a brief and simplified primer on the principles of video transmission. The video transmission primer assumes that the reader has previous knowledge of signal transmission, digital communications techniques, and sampling theory. However, for those readers who feel that more background information is needed, the books entitled *Electronic Communications Systems* by William D. Stanley, and the *Telecommunication Transmission Handbook, 2nd Edition*, by Roger L. Freeman, are excellent sources on the subject.

Because of the amount of information that must be translated by a full-motion video transmission system (luminance[2] values for approximately 224,264 pixels[3]) in an extremely short amount of time (microseconds), an extremely large bandwidth of transmission (B_T) is required for analog, full-motion video signal transmission (see Appendix A). The

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[2] Luminance is a measure of the distribution of light and shade that is exposed by a video image. The luminance of a moving image is interpreted in terms of its color, motion, and depth perspective.

[3] Each video frame is comprised of thousands of tiny square elements called pixels. The individual pixels within a video frame are scanned and assigned an 8-bit value of luminance. These luminance values are combined to create a representative code for the video image.

B_T is defined as the amount of bandwidth that "...is just sufficient to ensure the transmission of information at the rate and quality required under specified conditions." [Ref. 4] Providing for such a large B_T is very expensive because an analog, full-motion video signal (that has not been digitized and compressed by a compression algorithm) requires a transmission medium equal to a full satellite transponder (1920 voice channels).

The advent of digital signal processing made sharper and clearer video signals a reality. However, digital technology by itself did very little to reduce the large B_T for full-motion video signals and their associated high cost (in fact, the B_T increased). This is true because digital, full-motion video signals (without video compression) still required a B_T equal to 80 Mbps and higher. Fortunately, further advances in digital technology demonstrated that digital, full-motion video signals can be effectively compressed to reduce the bandwidth requirement (by the early 1960s, the bandwidth requirement had been effectively reduced to as low as 30 Mbps). [Ref. 5]

a. CODEC Functionality

The device that makes digital, full-motion video signal compression possible is the video CODEC. Figure 1 is a functional diagram of a typical video CODEC[4]. Video CODECs perform the following functions:

1. Analog-to-digital conversion of audio, full-motion video, and still graphics video signals.
2. Digital video signal (full-motion and graphics) demodulation.
3. Digital video signal (full-motion and graphics) coding and bandwidth reduction.
4. Digital audio time delay.
5. Multiplexing of the digital audio, full-motion video, still graphics video, and data signals.
6. Encryption of the multiplexed signal. [Ref. 3:p. 18.8]

Most CODEC manufacturers employ proprietary algorithms to carry out the process of encoding and compressing analog signals. First of all, the CODEC will perform analog-to-digital conversion on the incoming analog signals. Once the digital conversion is complete, the CODEC will execute a series of digital coding and bandwidth reduction operations.

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[4] This diagram assumes that the digital bit stream undergoes a digital-to-analog conversion at some juncture after the output of the line interface and prior to the transmission of the signal.

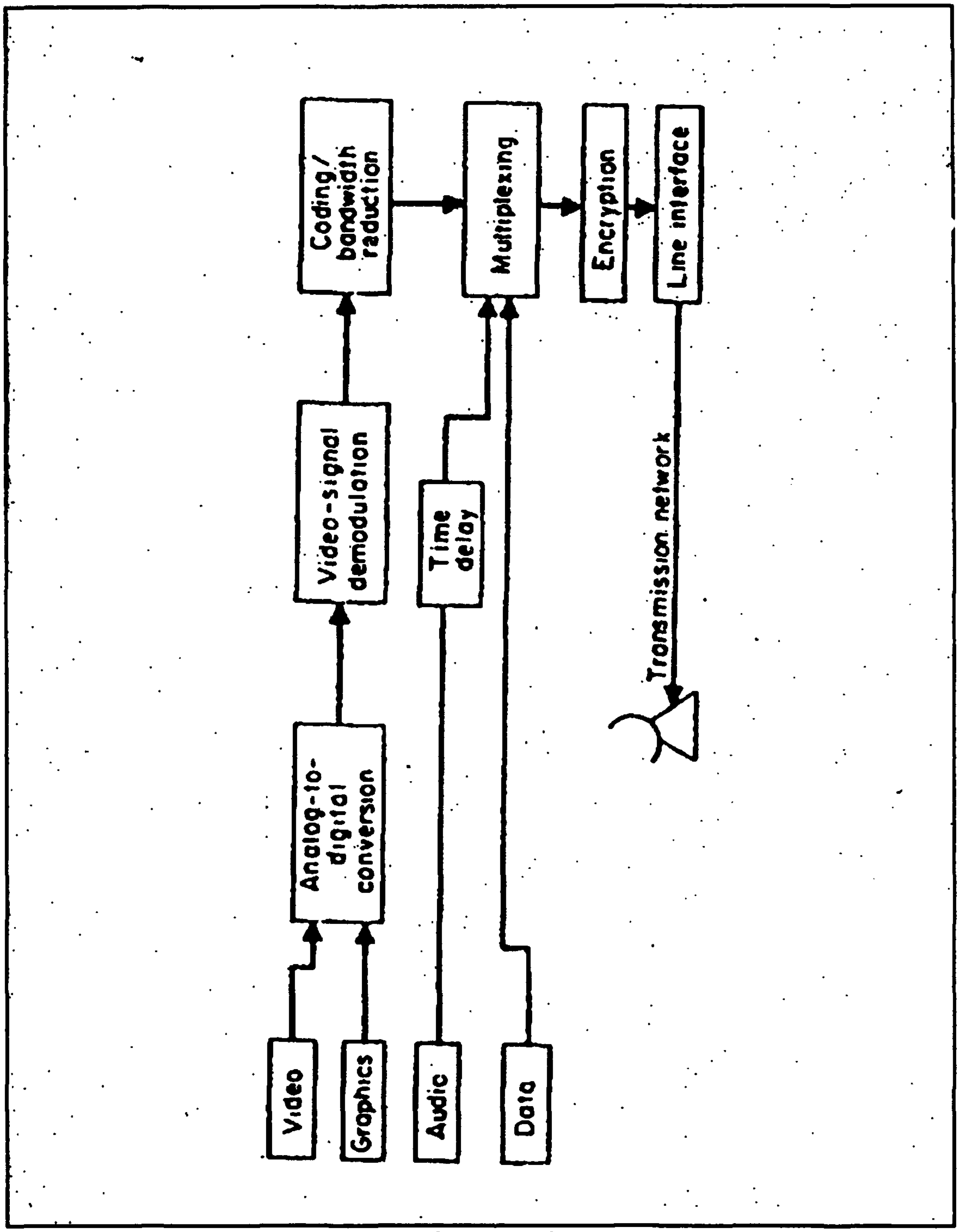

Figure 1 Video CODEC Functional Diagram[Ref. 3:p. 18.8]

Two techniques for data reduction that have been around for a long time are field (or pixel) elimination and frame elimination (please refer to Appendix A for an explanation of a pixel and a video frame). Field elimination involves the removal of either the odd or even numbered pixels within a video frame. This reduces the number of pixels that have to be encoded by one-half. Frame elimination involves the reduction of the overall number of frames to be encoded. These techniques work best in situations where motion is very limited because the picture quality is reduced as a result of the data compression. [Ref.3:p. 18.8]

Besides these earlier techniques, some CODECs employ modern techniques such as intraframe and interframe coding. These methods of compression take advantage of the redundancies in the pixels of a given video field and the nonlinearities of human vision. To achieve compression, these techniques exploit the correlation of the pixels for a video signal in both space and time. "Compression in space is known as intraframe coding, while compression in time is known as interframe coding." [Ref. 6]

Intraframe coding works by eliminating redundancy within a video frame and creating a representative code for the data [Ref. 3:p. 18.8]. This is accomplished by eliminating certain pixels from consideration in the coding sequence. If a particular pixel within a frame has a matching value for luminance, movement, and depth perspective with any of the previous pixels, it is passed over during the coding sequence.

Interframe coding, on the other hand, eliminates the redundancy between consecutive frames by transmitting only the differences (or changes) in luminance, movement, and depth perspective [Ref. 3:p. 18.8]. If these factors are constant between consecutive frames, the coded value of the first frame in the sequence will continue to be transmitted. However, if any of the factors above (luminance, motion, and depth perspective) should happen to change, the coded value from the first frame in the sequence will also change. After this occurs, a new coded value will be transmitted.

When a CODEC employs video compression, there is a tradeoff between the B_T and the picture quality. <u>As the B_T is lowered, the motion-handling capacity and picture resolution are degraded</u>. To compensate for this dilemma, more sophisticated encoding is necessary as the B_T is reduced. However, picture irregularities may still occur during the transition from medium to high motion.

Graphics are usually transmitted in static form. Although graphics are compressed in space just like full-motion video, graphics are transmitted one frame at a time by interleaving a single graphics frame within the full-motion video frames. The result of this interleaving is a freezing of the full-motion video signal for a period of ½ to 1½ seconds, while the single graphics frame is transmitted. [Ref. 3:p.18.9]

CODECs initiate a time-delay for audio signals so that the audio is synchronized with the video. Then the audio, video and data signals are multiplexed into a bit stream for final encryption and signal transmission. [Ref. 3:p. 18.8]

b. CODEC Evolution

Full-motion video CODECs have been in use since the 1960s. However, these early CODECs still utilized a significant amount of bandwidth, requiring a B_T of approximately 30 Mbps (as mentioned earlier). By the late 1970s, satellite communications and less expensive CODECs that could operate at a B_T of 3 Mbps or less began to emerge, which made it possible for large organizations to justify economically the purchase and utilization of VTC systems.

In 1982, CODECs were developed that lowered the bandwidth requirement even further. These CODECs could operate on the AT&T standard transmission facility, T1 (see Appendix B for more details on T1 networking). This was a significant development because T1 transmission facilities operate at the Digital Signal (DS) designation DS1[5] data rate

[5] The voice-digitization rate (VDR) that serves as the nucleus for the entire series of AT&T's Digital Signal Designations is 64 kbps, which is defined as DS0. DS1 is defined as the equivalent of 24 DS0 channels, or 1.544 Mbps.

of 1.544 Mbps (equivalent to 24 voice channels), offering many advantages for VTC transmission. The most important advantage of T1 is its bandwidth capacity. The T1 transmission facility is large enough to sufficiently transmit VTC signals that have been compressed below the DS1 data rate. Other advantages are the amount of bandwidth that is available for the transmission of VTC signals, the availability of terrestrial communications media for the transport of the VTC signals (which eliminates the requirement for expensive satellite communications), and the reduction in VTC transmission costs. Further improvements made it possible for CODECs to operate at fractional T1 data rates, which reduced the cost even further. In recent years, CODEC manufacturers have been directing their efforts to reduce the B_T that is necessary for VTC. The majority of CODEC manufacturers have focused their efforts on producing low-bandwidth CODECs (56 kbps - 384 kbps) for low cost VTC and high-bandwidth CODECs (384 kbps - 2.048 Mbps) for high picture quality VTC[6]. Some CODEC manufacturers even offer CODECs that can operate at every bandwidth from 56 kbps to 2.048 Mbps, which offers flexibility in deciding VTC cost versus VTC picture quality.

The technological breakthroughs that have reduced VTC bandwidth requirements have created a wider variety of

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[6] 384 kbps is quite often the cut-off point between high-bandwidth and low-bandwidth VTC. Therefore, 384 kbps is usually included on both high-bandwidth and low-bandwidth CODECs.

transmission services for VTC. Each of these transmission services offers its own particular advantages for VTC. [Ref. 5:pp. 4-6]

2. Transmission Services

Currently, there are several standard transmission data rates available internationally. For example, in Europe the E1[7] transmission facility operates at the rate of thirty-two 64 kbps channels, or 2.048 Mbps. This varies considerably from the T1 standard in the United States (1.544 Mbps). This is a serious problem because the CODEC manufacturers from various nations are producing CODECs to match the established transmission facility standard that their countries have adopted.

In today's world of international competition and participation in highly diversified business ventures, communication to widely dispersed locations across international boundaries can be quite burdensome. Without special and often expensive arrangements, the various transmission services that operate at different data rates cannot be linked together. This means that special equipment (transmission gateways and bridges) will be needed for transmission services to function internationally until

[7] E1 is the European standard transmission facility. E1 capacity is specified at 2.048 Mbps.

international standards for transmission rates can be established. In fact:

> The growing interdependence of the world economic community has greatly increased the importance of worldwide standardization in communications. As a result, the standardization activities of the (Comité Consultatif International de Téléphone et Télégraph) CCITT are being monitored by every service vendor in this country and abroad. [Ref. 5:p. 7]

C. FUTURE DEVELOPMENTS IN VTC

In the discussion of CODEC improvements and telecommunications services that follows, it is assumed that the reader is abreast of issues related to the Integrated Services Digital Network (ISDN) standards, the Federal Telecommunications Service (FTS)2000, the Open Systems Interconnection (OSI) Protocols, and the Navy Base Information Transfer System (BITS). Please refer to Appendices C (ISDN Primer), D (OSI Protocols Primer), E (Navy BITS Primer), and F (FTS2000 Primer) for a brief review on those subjects.

If the ISDN and OSI primers are insufficient, the book entitled *Data Networks* by Uyless Black is an excellent source for obtaining knowledge about these subjects. Also, if the FTS2000 and Navy BITS primers are insufficient, the General Services Administration (GSA), AT&T, and U.S. Sprint can be contacted to provide more detailed information on FTS2000, while the Commander, Naval Computers and Telecommunications Command (NCTC) code N43 (Base Communications) can be contacted to provide more information on BITS.

1. Next Generation of Video CODECs

CODEC manufacturers have been concentrating their efforts on developing their systems to offer a wide service utility at bandwidths from 56 kbps to 2.048 Mbps. However, in light of the developments of ISDN, CODEC manufacturers are shifting their focus to produce quality, full-motion video images at multiples of 64 kbps up to 384 kbps. [Ref. 5:p. 8]

> Video Compression is expected to change the world forever. It will ...provide the catalyst to launch ISDN. [Ref. 7]

VTC at 64 kbps and 384 kbps will have a positive impact on the future development of ISDN because these rates are well suited for the ISDN Basic Rate Interface (BRI) and Primary Rate Interface (PRI). The ISDN BRI is capable of handling two 64 kbps VTC channels (with 16 kbps left over as control bits). The ISDN PRI, on the other hand, is capable of handling twenty-three 64 kbps VTC channels (with 64 kbps left over as control bits). The ISDN PRI can also accommodate three 384 kbps VTC channels with plenty of room to spare.

The ISDN PRI is likely to become the most widely used VTC user-network interface because it gives VTC users the flexibility to conduct either low-bandwidth or high-bandwidth video teleconferences. The ISDN PRI can handle low-bandwidth video teleconferences at rates such as 64 kbps or 128 kbps, leaving plenty of excess bandwidth for other uses. The ISDN PRI can also handle high-bandwidth video teleconferences at rates such as 384 kbps or 768 kbps and still have plenty of excess bandwidth for other uses. This is the kind of flexibility that makes ISDN very appealing to VTC users.

a. *CCITT H.261 Algorithm*

In December 1990, the CCITT membership ratified the H.261 algorithm as the new video compression standard. H.261 (also known as **P x 64**) is based on a proprietary algorithm known as Discrete Cosine Transform (DCT) which is essentially a standardized method for decoding a video bit stream to provide universal compatibility and connectivity. [Ref. 8]

> Analysts say widespread acquisition of standards-based interfaces will prompt more companies to communicate with suppliers and customers, a capability now available mainly through gateway services provided by interexchange carriers (IXCs)[8] such as AT&T, Microwave Communications, Incorporated (MCI), and U.S. Sprint. [Ref. 9]

Bob Keiper, the president of KAI, states that, "H.261 offers a very important new capability for VTC. It offers superior quality at every data rate between 56 Kbps and 2.048 Mbps." [Ref. 10]

H.261 is expected to be the driving factor in lower CODEC prices, and CODEC manufacturers are expected to take immediate measures to install the H.261 hardware or software upgrades in their CODECs. In fact, analysts predict that digital signal processing chips containing the H.261 algorithm

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[8] IXC is a new term that refers to the **long-distance** voice and data carriers since the divestiture of AT&T in 1984.

will become the mainstay of the CODEC manufacturing industry. [Ref. 9:pp. 37-38]

b. CLI's Rembrandt Family of Video CODECs

Compression Labs, Incorporated (CLI), the manufacturer of the Rembrandt® family of CODECs, including the Rembrandt, Rembrandt 56, Rembrandt II/06, and the Rembrandt II/VP is the exclusive CODEC vendor for FTS2000 [Ref. 11]. CLI is also recognized as the world leader in CODEC sales and distribution [Ref. 12].

The Rembrandt CODEC has dominated the high-bandwidth VTC market (384 kbps - 2.048 Mbps) since the mid 1980s. It has been a favorite of those customers who need the type of picture quality that this high-bandwidth CODEC can produce. The Rembrandt 56, on the other hand, has been slowly phased out of production in the low-bandwidth VTC market. This is because the Rembrandt II/06's newer proprietary algorithm "...improved picture quality 2:1 over CLI's previous low-bandwidth algorithm." [Ref. 13]

According to John Tyson, the President of CLI:

> It (Rembrandt II/06) provides the picture quality breakthrough that the market has been waiting for and the flexibility to adapt to the dramatic changes that we see ahead for this segment of the market...Rembrandt II/06 offers international connectivity right from the start. And since the Rembrandt II/06 was **designed from its conception to run P x 64**, we are at the forefront of the industry in terms of standards compatibility. [Ref. 8:pp. 1-2]

Here are a few of the Rembrandt II/06 video CODEC's most significant features:

1. Superior picture quality at transmission rates of 56 Kbps - 384 Kbps over switched and dedicated networks [Ref. 14].

2. The Flex5™ architecture, which offers a combination of hardware and software flexibility for widespread compatibility and connectivity. It allows users to add new features, modes or interfaces by inserting a new software cartridge or by plugging additional circuit boards into Rembrandt II/06's open slots [Ref. 8:p. 2].

3. The Cosine Transform Extended (CTX™) algorithm, which utilizes **the same DCT technology as the CCITT's H.261 video compression standard** [Ref. 11:p. 5].

4. New technology that has been developed by chip manufacturers, which enables the DCT chip to perform the same compression algorithm that formerly required three circuit boards to execute [Ref. 15].

The new Rembrandt II/VP, which was introduced during the third quarter of fiscal year (FY) 1991, will further improve VTC quality by integrating the capabilities of CLI's low-bandwidth and high-bandwidth products. Rembrandt II/VP will allow its users to send their VTC transmissions at any rate from 56 kbps to 2.048 Mbps and will **fully incorporate the H.261 standard** (Rembrandt II/06 merely utilizes the DCT technology on which H.261 is based). [Ref. 16]

> At speeds greater than 384 kbps, the price performance of the Rembrandt II/VP line is much better than high-end systems from NEC America, Inc. and GPT Video Systems. At lesser speeds, the product offers similar picture quality to videoconferencing systems from PictureTel Corp. but costs 6% to 22% more.... [Ref. 17]

The Rembrandt II/VP is truly the first applications driven CODEC. It will support formal, large group presentations that require the exceptional picture quality of a high-bandwidth CODEC and will also support those informal briefings that are best served by the picture quality of a low-bandwidth CODEC.

> This means project team members can dial up a videoconference to compare notes at a economical 112 kbps. Division managers can discuss strategic issues at 384 kbps. And top management can put on its best face for a prospective client at 768 kbps or higher - all in the same videoconferencing room using the same CODEC. [Ref. 18]

The Rembrandt II/VP operates on a specialized microprocessing chip called the Vision Processor (VP), that was developed by Integrated Information Technology (IIT) in cooperation with CLI. The VP chip supplies the Rembrandt II/VP with its tremendous processing power. In fact, the Rembrandt II/VP can process more than five billion operations per second. This is essential, because any one of the four application packages that are available with the Rembrandt II/VP can execute a variety of complex algorithms (including the CCITT standard and a variety of CLI's proprietary algorithms). [Ref. 8:p. 5]

For those CLI customers who currently use the Rembrandt 56 and Rembrandt II/06, the FLEX5 architecture will allow them to upgrade to the Rembrandt II/VP CODEC by a simple swap-out of the video-processing boards. This type of flexibility is extremely important because it allows growth to occur without the demanding expense of backfitting the existing VTC system. [Ref. 16:p. 10]

2. Recent Proposals for Improving Telecommunications Services

In an attempt to map out a planned future for international telecommunications, all (customers, vendors, and regulatory boards) have agreed that the primary objective for future transmission services is to offer specified bandwidths that are capable of handling a wide array of telecommunications services (i.e., voice, data, imaging, and video) over the same transmission facilities. However, there are still unresolved problems that make this objective difficult to achieve - namely standardization, interoperability, and interconnectivity. Standardization organizations and equipment manufacturers are doing their part to resolve the standardization and interoperability problems. However, it is up to the providers of transmission services to resolve the interconnectivty problem.

Through migration of Navy communications systems to the ISDN and the OSI protocols, the integration of voice, data, imaging, and video communications systems will become a reality. This migration will also assist in eliminating the duplication of resources and accelerate the arrival of new services such as electronic mail (E-mail) and VTC.

a. Integrated Services Digital Network (ISDN)

ISDN is the CCITT's proposal for providing specified bandwidths that can support a wide range of telecommunications services over shared transmission facilities (see Appendix C). ISDN will support a wide spectrum of user needs including digitized voice, data applications (E-mail, file transfer. etc.), FAX, and digitized image (both full-motion and still frame).

> ISDN is a network architecture using digital technology to support integrated voice, data, and image services through standard interfaces over standard twisted-pair telephone wire. Evolving from the early piecepart deployment of digital switching, digital transmission capability, and common channel signaling, the telecommunications industry recognizes ISDN as the means of integrating telecommunications services and modernizing public networks to make information movement and management more efficient. [Ref. 19]

ISDN will be a world-wide, public telecommunications network that will eliminate the duplication of resources by integrating voice, data, FAX, and digitized image communications systems, and enhancing mission support. ISDN will also allow the use of commercial off-the-shelf (COTS) products once the equipment vendors adhere to the OSI standards (see Appendix D). When this happens, customers will be able to buy COTS products and know that these products will be compatible with ISDN.

> Experts say that as we approach the limits of the phone system, it will create an increased demand for ISDN, which will permit faster data transfer simultaneously on the same lines used for voice communications. This should inspire higher quality electronic consumer services, which so far have struggled to gain acceptance. [Ref. 20]

VTC is expected to greatly benefit from the implementation of ISDN. When ISDN is finally implemented, those vendors who can offer VTC equipment that is optimized at the lower rates offered by ISDN will be rewarded by higher sales [Ref. 5:p. 8]. Also, the rollout of more digital switched services (including ISDN) will help to establish a large installed base of VTC users [Ref. 21]. However, a major drawback is the telecommunications industry's failure to fully integrate ISDN in North America. North American ISDN vendors have developed prototypes and begun to market ISDN products, but they lag behind their counterparts in Europe and Japan. The telecommunications industry in Europe and Japan (free of regulation) has taken steps towards full migration to ISDN. In fact, Europe is nearly finished and Japan has finished.

Part of the problem in North America is that federal and state regulators and legislatures continue to do battle with the telecommunications industry over issues that continue to hinder the progress of ISDN. For example:

> The experience in the telecommunications industry has encompassed unsuccessful legislation by the Congress, industry restructuring by the Justice Department, deregulation of communications equipment by the FCC, and piecemeal restructuring of long distance markets by the FCC and the courts. [Ref. 22]

b. Navy Base Information Transfer System (BITS)

Currently, there is an urgent need to modernize Navy communications systems. The major emphasis of the BITS sub-architecture is to assist Navy communications to migrate to the ISDN and OSI standards for streamlining Navy base communications (See Appendix D for a primer on the OSI protocols and Appendix E for a primer on BITS).

> The objective of the BITS sub-architecture is to integrate the existing independent communications systems in Navy bases through a backbone transmission and switching system to provide voice, data, imaging, and video communications services. [Ref. 23]

As seen in Figure 2, the BITS sub-architecture will integrate the following services for Navy base communications:

1. File Transfer
2. Interactive Mode
3. E-Mail
4. VTC
5. Record Communications
6. Security
7. Communications

In the BITS sub-architecture, intrabase data communications will be provided via local area networks (LANs). These LANs will ensure interoperability by requiring systems on the LAN to internetwork with each other, including shipboard systems. Interbase communications will be provided via the Defense Message System (DMS), the Defense Switched Network (DSN), the Defense Data Network (DDN), and dedicated point-to-point networks (like FTS2000).

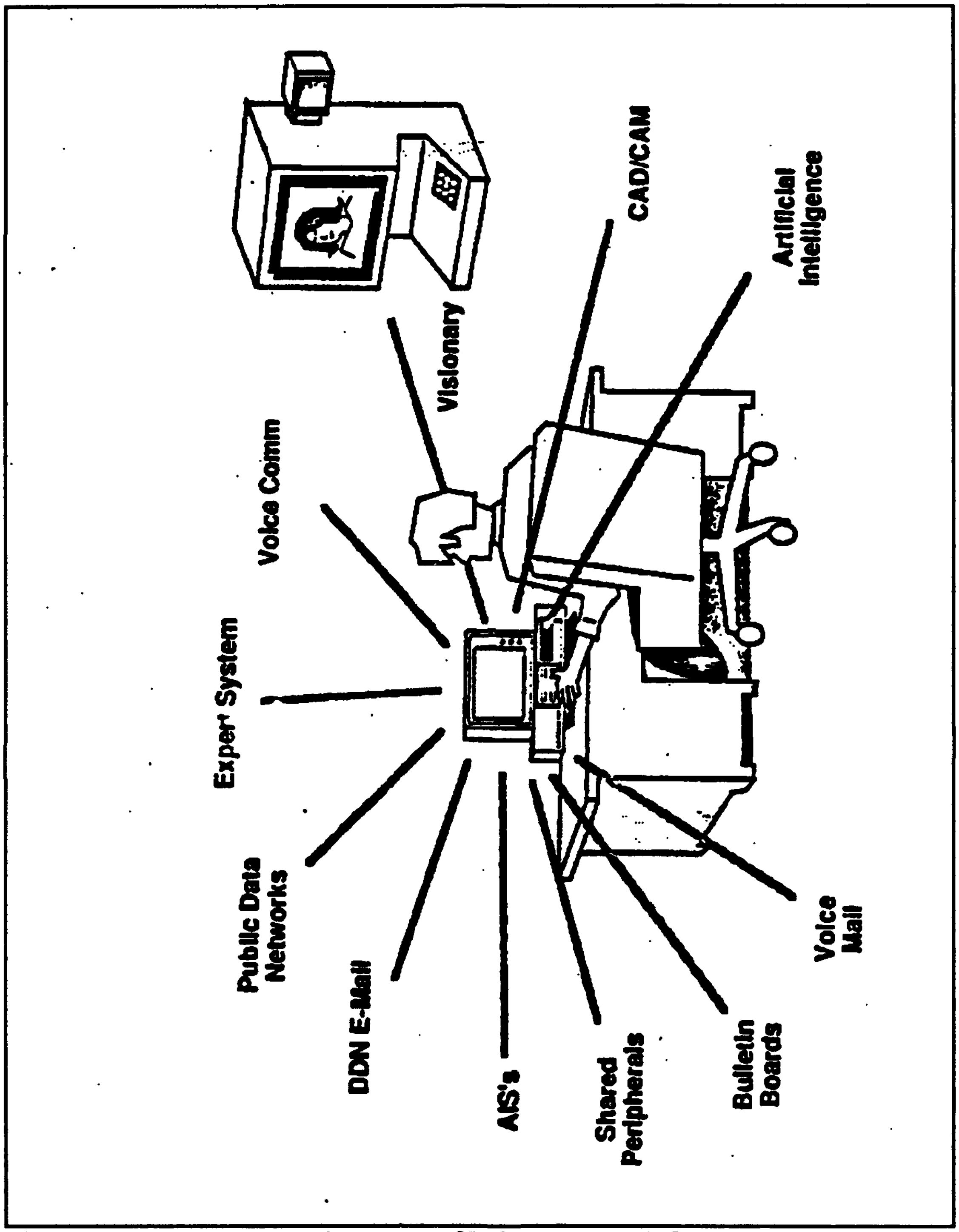

Figure 2 BITS Integrated Services[Ref. 23:p. 3-16]

c. Federal Telecommunications Service (FTS)2000

FTS2000 is a concept that will provide all federal government agencies with a modern, low-cost telecommunications network and services (see Appendix F). FTS2000 will provide these agencies with integrated voice, data, and imaging services.

> The FTS2000 network uses state-of-the-art digital and fiber optic technology and is designed to carry the federal government into the next telecommunications millennium. As the largest civilian government contract in history, its scope is staggering. FTS2000 will eventually provide long-distance telecommunications service to a user base of 1.4 million federal workers at 3,500 locations. [Ref. 24]

As explained in the draft DOD Directive entitled *Teleconferencing Activities, Systems and Networks*, all branches of the DOD will use FTS2000 for long haul teleconferencing (VTC included), unless an exemption has been decreed by the Warner Amendment[9] [Ref. 2:p. 3]. This draft DOD instruction is not in effect as of this writing, but it is expected to be released soon.

One of the many service features that is offered with FTS2000 is the Video Transmission Service (VTS). The FTS2000 VTS is available in both wideband and a compressed, full-motion video service. The Compressed Video Transmission Service (CVTS) offers interactive (two-way), point-to-point VTC plus broadcast (one-way), point-to-multipoint VTC.

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[9] The Warner Amendment allows exemptions for special telecommunications requirements such as command and control (C^2).

> Videoconferencing was built into FTS2000 because of its potential to improve productivity, reduce travel costs and improve communication and decision making for government agencies and employees. [Ref. 11:p. 2]

Recently, the FTS2000 contract has come under considerable scrutiny, with much of the controversy centered around the DON. The GSA's handling of the FTS2000 contract has also come under harsh criticism from Congressional leaders, the Government Accounting Office (GAO), and several federal agencies.

To begin with, the original FTS2000 contract called for the entire DOD to be assigned to Network A (AT&T). But last October 1990, the DON was traded to Network B (U.S. Sprint) in a controversial move.

> Testimony from GSA officials during a House hearing last spring revealed that the GSA traded the Navy's business to U.S. Sprint for lower prices [Ref. 25]

During the first week of August 1991, the GSA responded to Congressional pressure and reassigned the DON back to Network A. This move was designed to soothe Congressional criticism of the GSA for failing to deliver 60 percent of the FTS2000 revenues to AT&T (the low bidder). [Ref. 25:p. 4]

Congress has not been the only group to be critical of FTS2000. The trouble started in June 1991, when the GSA attempted to further appease Congress and ensure that AT&T received its fair share of the FTS2000 revenues. The GSA ordered several federal agencies, including the Department of

Energy (DOE), the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the Tennessee Valley Authority (TVA), and others, to scrap the expansion plans for their existing telecommunications networks and comply with FTS2000. These federal agencies became exceedingly outraged because the GSA had withdrawn a previous exemption to FTS2000 (that had been granted to them in 1988[10]). [Ref. 26]

Once the order became effective, these federal agencies began a highly publicized campaign to save their existing telecommunications networks. They insisted that FTS2000 services were inadequate and more expensive than other network offerings [Ref. 27]. Naturally, Congress became increasingly alarmed by these accusations and ordered a full scale hearing to investigate complaints about FTS2000 services [Ref. 25:p. 4].

At the same time, the GAO issued a report that supported customers complaints about inflated prices for FTS2000 services [Ref. 28]. It was becoming apparent that the future of the FTS2000 contract might be in jeopardy.

Meanwhile, the GSA had appointed a new point man for FTS2000 - Donald Scott. Scott insisted that the GSA would enter into contract discussions with AT&T and U.S. Sprint to set a cap on FTS2000 services. Scott also planned to arrange

[10] The DOE and the FAA have recently regained their previous exemptions from using FTS2000.

for additional enhanced services and to streamline the billing process for more efficiency. [Ref. 29]

Scott was successful in arranging a negotiated price cap that will automatically adjust FTS2000 rates to reflect commercial rates [Ref. 30]. The negotiations for new service enhancements and a streamlined billing process are still in progress, but Scott insists that these issues will have top priority in the coming year [Ref. 29: p. 15].

Even though Congress has been unsettled by all of the well-publicized "mudslinging" concerning the FTS2000 contract, many members of the Senate and the House of Representatives remain committed to seeing the FTS2000 network come to fruition. As evidence of Congressional support for the FTS2000 network, the House of Representatives passed *House Resolution (H.R.) 3161, The Federal Property and Administrative Services Authorization Act of 1991.*

One of the key provisions of *H.R. 3161* requires all agencies to use FTS2000 for any covered service and product and emphasizes that the GSA is not allowed to authorize agencies to do otherwise [Ref. 31]. This resolution, along with the GSA's determination to enforce federal compliance with FTS2000, is proof that federal agencies (including the DON) should seriously consider FTS2000 service offerings (including CVTS) before they attempt to procure these services elsewhere.

Finally, Congress has set a FTS2000 hearing for December 1992. At this hearing, the performance of AT&T and U.S. Sprint will be evaluated[11]. At that time, each vendor will have an opportunity to win up to 40 percent of the other vendor's FTS2000 business (a move that was designed to ensure competition during the lifetime of the contract). [Ref. 32]

d. Switched Data Services

More and more VTC users are utilizing switched data services for VTC signal transmission instead of dedicated transmission facilities. Switched data services utilize switched digital networks that select the most time and cost efficient paths for data signals to travel during transmission between sites. Data switching is accomplished by solid state digital switches that are located at various switching centers (or "nodes") along the various paths. [Ref. 4:p. 194]

> Switched data services offer more flexibility and greater features than ever before - and at more reasonable costs. Some switched 56 kbps... data services are no more expensive than standard private-line voice services (that have a maximum capacity of 30.8 kbps). [Ref. 33]

Developments such as ISDN, FTS2000, and BITS indicate that lower costs and greater switched data service functionality will be provided for many customers in the near future. In fact, the major IXCs such as AT&T, MCI, and U.S.

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[11] The FTS2000 contract calls for periodic reviews of AT&T's and U.S. Sprint's performance in meeting the terms of the contract.

Sprint are all dedicated to switched data service development. Some of the local exchange carriers (LECs)[12], like Pacific Bell (PACBELL) and Southern Bell, are also involved in the development of switched data services. [Ref. 33:p. 34]

One of the functions that switched data services can accommodate is VTC. Switched data services are extremely promising for the VTC industry because their inexpensive nature allows for lower transmission cost of VTC signals. Switched data services can be utilized for VTC transmission within an LEC's territory or via an IXC's VTC network.

(1) AT&T

AT&T offers a wide variety of switched data services, including the ACUNET Switched Digital Services (SDS) for public network customers, and the Software-Defined Data Network (SDDN) for its Software-Defined Network (SDN) users. The SDS and SDDN currently offer 56 kbps, 64 kbps, and 384 kbps switched data services. AT&T also plans to provide a 1.536 Mbps switched data service, which corresponds with the capacity of the ISDN H11-channel, by the end of 1991 (see Appendix C).

The capabilities of SDN (of which SDDN is an option) are linking with the switched data services of ACUNET SDS. Access to the network is through ISDN PRI.

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[12]LEC is a new term that refers to the local telephone companies since the divestiture of AT&T in 1984.

SDDN will enable users to dial up multiple connections for higher amounts of bandwidth. For instance, a user that wants 384 kbps of bandwidth for an application, such as VTC, could dial up six 64 kbps lines to get 384 kbps (remember, the picture quality increases with bandwidth). [Ref. 33:p. 35]

(2) MCI and U.S. Sprint

MCI also offers a 56 kbps switched data service. MCI offers this service as a dedicated service known as the Prism 56 or as part of the Vnet virtual network[13]. MCI also plans to offer a 64 kbps switched data service on Vnet service by late 1991. Additionally, MCI is making moves to introduce ISDN services that will furnish its customers with high-volume, host-to-host data transmission via PRI access. MCI's initial ISDN offering will rely on 64 kbps service; however, the Digital Reconfiguration Service (DRS) will allow its customers to demand more bandwidth in increments of 64 kbps up to and including 1.544 Mbps. [Ref. 33:p. 35]

MCI's contributions to switched data services will have a minimal impact on the government sector because it was not included in the FTS2000 contract. However, MCI does figure to play a significant role in the private sector.

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[13] The Vnet virtual network is a switched data network that permits the customer to specify the amount of bandwidth that is needed for a particular application (up to and including T1). This service is often referred to as bandwidth on demand. The advantage of this type of network is that the customer only pays for that amount of bandwidth that is actually being used vice the entire T1 capacity.

U.S. Sprint is also engaged in numerous ventures to provide its customers with switched data services. Its core business is the VPN 56[14], but it also provides some exclusive service offerings to the federal government through the FTS2000. [Ref. 33:p. 39]

(3) Local Exchange Carriers (LECs)

Various LECs including PACBELL have their own switched data service offerings. Most LECs are pledging to offer data for the price of voice and are diligently working at developing switched 56 kbps services.

PACBELL has four switched data service offerings with plans for another addition in the near future. PACBELL has also unveiled ISDN PRI service that will allow its customers to internetwork within its service area at a rate of 64 kbps.

D. VTC USER COMMUNITY

In the past, serious doubt was raised by decision makers about how their organizations would respond to the implementation of VTC and what this new technology could possibly do to benefit their organizations. After many years of excruciating and detailed cost-benefit analyses of VTC and travel displacement, more and more VTC users are stating that the cost savings associated with travel reductions are a minor

[14] VPN 56 is also a virtual switched network that provides bandwidth options of 56 kbps or 112 kbps (dual 56 kbps lines).

benefit of VTC. In fact, the VTC users have been persistent in stating that productivity enhancements in the workplace are the major benefits of VTC. [Ref. 5:p. 9]

For example, Robert W. Moench, President of Pacific Power and Light (PP&L), states:

> We needed to get people together face-to-face, but we couldn't afford to spend all the time traveling back and forth. We have different cultures that need to merge into one, and we weren't sure whether videoconferencing was going to work for that. But it is doing a great job of passing along that unspoken communication - such as body language and voice inflection - that we thought we could only get from a direct, interpersonal discussion. [Ref. 34]

As another example, in 1987, the University of Missouri system installed a VTC network that allowed specialized classes offered at one campus to be offered to students throughout the system. Video classes instantly became a huge success. C. Peter Magrath, President of the University of Missouri system, notes the following:

> The response from both students and faculty has been very favorable. Unlike one-way instruction, videoconferencing lets people see each other and talk back and forth. Today, we carry about 44 hours of classes per week on the network. [Ref. 34:p. 15]

Finally, R. Craig Christie, President of Bendix/King, relates how the design engineers in Olathe, Kansas, the manufacturing people in Lawrence, Kansas, and the systems and program management people in Ft. Lauderdale, Florida, interface with one another.

> We'd have weekly meetings over the video link. Engineers would have design discussions, projecting block and circuit diagrams on the television screen in Ft. Lauderdale. We'd also use the network for in-depth program reviews. Videoconferencing lets a lot more people participate than if you had to fly everyone down to Florida. When you look at how much time it's saved us, videoconferencing has been just unbelievable.
> [Ref. 34:p. 11]

The testimonies of Robert W. Moench, C. Peter Magrath, and R. Craig Christie support the notion that the productivity enhancements that VTC can offer to an organization far outweigh the displacement of travel that VTC may or may not provide. In fact, their statements shed some powerful insight on some possible applications for VTC at NPS.

III. TOOLS AND TECHNIQUES USED TO COMPLETE THE VTC FEASIBILITY STUDY

> Applying the tools and techniques of systems analysis... in the classroom is easy. Applying those same tools and techniques in the real world may not work... that is, if they are not complemented by effective methods for collecting facts. Tools document facts, and conclusions are drawn from facts. If you can't collect the facts, you can't use the tools.... [Ref. 1:p. 726]

In the process of conducting a VTC feasibility study at NPS, it is extremely important to present facts about the nature of the opportunities that this exciting new technology can provide. It is also necessary to present the nature of certain problems that are associated with travelling to meetings to conduct business.

To obtain the facts related to the VTC feasibility study, five common fact-finding techniques were applied. These fact-finding techniques include:

1. Sampling existing documentation, forms, and files.
2. Research and site visits.
3. Observation of the work environment.
4. Questionnaires.
5. Interviews and group work sessions. [Ref. 1:p. 727]

A. SAMPLING EXISTING DOCUMENTATION, FORMS, FILES, AND BOOKS

The first document that was utilized to gain an understanding of the organization at NPS was the Standard

Organization and Regulations Manual (SORM). The SORM was beneficial in identifying the administrative staff and the faculty department chairmen as the primary positions within the NPS organization that could possibly benefit from the implementation of VTC. Even though these groups represent a small population at NPS (28 people), their job requirements are significant enough to produce a considerable strain on their time and budget. This is why they were targeted as the possible end users.

Additionally, documentation that traced the history of VTC investigation at NPS was solicited from members of the administrative staff. However, no additional documentation was available. It seems that this feasibility study was the first serious effort to research VTC implementation at NPS.

Next, travel data was obtained in an effort to learn more about the nature of the problems related to travelling to meetings to conduct business. Even though travel displacement is not considered as important as productivity enhancements, travel data is very useful when trying to learn more about the tendencies of business travel at NPS. Accounting records that detailed the mode of travel, purpose for the travel, the source of funding for the travel, and the amount of money that was obligated for the travel were secured through the Personnel Support Detachment (PSD) travel office. Secondly, travel budget data that accurately assessed the amount of money obligated (checks written) for travel at NPS during FY 1990 was obtained through the Comptroller's Office.

B. RESEARCH AND SITE VISITS

Because of the evolving nature of VTC and the issues related to VTC procurement, thorough research was required to obtain a sufficient understanding of the opportunities that VTC can present. Trade journals including those from the Institute of Electrical and Electronics Engineers (IEEE) and the International Teleconferencing Association (ITCA) were extremely helpful in pinpointing specific VTC details and issues such as VTC economics data. Also, publications from VTC consultants, VTC products manufacturers, and VTC reference materials were instrumental in understanding VTC procurement issues and VTC applications.

Instrumental to this effort was the knowledge that was gained through the "hands-on" learning and the eyewitness accounts that were acquired by visiting three VTC facilities. It was truly advantageous to solicit VTC procurement information from those organizations that had previously encountered the same VTC feasibility issues that NPS is currently facing.

C. OBSERVATION OF THE WORK ENVIRONMENT

Site visits to VTC facilities at the Naval Surface Weapons Systems Engineering Station (NSWSES), Port Hueneme, California; the Pacific Missile Test Center (PMTC), Point Mugu, California; and Fort Ord in Monterey, California, provided the author with an opportunity to meet face-to-face with VTC managers who are responsible for the operation and maintenance of these facilities. It also provided valuable insight into the everyday operation of typical VTC facilities.

By skillful observation of these VTC facilities, highly reliable data was gathered from individuals who were very familiar with the operation of their VTC facility. Also, VTC operations that had previously been very difficult to grasp through reading and conversation were now made easy to discern. VTC system demonstrations and actual participation in video teleconferences allowed for crucial "hands-on" training that is simply not accessible through reading or conversation.

D. QUESTIONNAIRES

The use of questionnaires is often controversial and heavily criticized. But despite the aggravation of knowing that many people do not appreciate questionnaires, they are useful tools for gathering facts. Questionnaires have certain advantages that allow an analyst to ascertain the nature of any current problem:

1. Most questionnaires can be answered quickly. People can complete and return questionnaires at their convenience.

2. Questionnaires provide a relatively inexpensive means for gathering data from a large number of individuals.

3. Questionnaires allow individuals to maintain anonymity. Therefore, individuals are more likely to provide the real facts. [Ref. 1:p. 733]

Questionnaires also have a few disadvantages. First of all, the number of respondents to a questionnaire is often very low. Also, there are no guarantees that individuals will provide factual responses that pertain to the essence of the subject matter. Finally, there is no opportunity to clarify a vague or incomplete question once the questionnaire has been distributed. Despite these problems, the author felt that the use of questionnaires was justified because a large number of individuals at NPS needed to be reached in a very short amount of time.

Questionnaires were needed to gain a reasonable understanding of the problems that generated an interest in VTC at NPS. The questionnaires were also needed to examine the work and educational environment at NPS in an attempt to uncover any problems or unresolved opportunities that might be responsive to a VTC solution.

To design the questionnaire, a great deal of time and effort was expended to ensure that the questionnaire would be beneficial. The following procedures were followed:

1. A determination was made concerning what facts and opinions must be collected and from whom they should be solicited.

2. Based on the needed facts and opinions, a determination was made on whether free or fixed-format questions would produce the best answers.

3. The questions were also edited to ensure that they did not offer any personal bias or opinions.

4. The questions were tested on a small group of respondents. The questions were edited if the respondents had a problem with them or if the answers were not useful. [Ref. 1:p. 735]

The type of questionnaire that was chosen was the free-format[15] questionnaire. This format was chosen because the respondents needed considerable latitude in responding to the questionnaires in order for them to be useful. Even though the responses did not always match the questions that were asked, and even though they were difficult to tabulate for analysis, a great sum of useful information was generated as a result of this format.

The "VTC Users' Analysis Questionnaire" (see Appendix G) was hand delivered to certain members of the administrative staff and the faculty department chairmen. There were two main purposes for hand delivering the questionnaires. The first was the author's desire to personalize the process. The author presumed that the respondents would be more likely to respond to the questionnaires and respond in a more timely fashion if they knew who the questionnaire was coming from,

[15] Free-format questions are the type of questions in which the answer is determined entirely by the respondent (i.e. What do you like to do?). Fixed-format questions, on the other hand, do not allow the respondents to develop their own answer. Instead, they must choose from a list of pre-determined answers (i.e. Do you like to run or swim?).

what it was all about, and why it was so important. This presumption proved to be successful.

Of the 26 individuals who were originally issued a questionnaire, 18 individuals responded (69.2 percent). In addition, two other individuals who were not originally furnished with a questionnaire responded because of their interest in the subject matter. This increased the percentage of those who responded to 71.4 percent.

The second reason for hand delivering the questionnaires was to give the author an opportunity to discuss VTC with the respondents and to gain an understanding of their knowledge and perceptions of VTC. This was extremely useful when it came time to analyze the questionnaires. Quite often, a respondents' ability to respond to the questions in a broad-minded fashion, while demonstrating an appropriate level of skepticism, was a direct reflection of his or her knowledge and perceptions of VTC.

Overall, the VTC User's Analysis Questionnaire did not provide sufficient details to be useful for this study. The responses were often too general, and it was nearly impossible to make any educated conclusions from the responses. However, the surveys did indicate which respondents should be approached to participate in a group work session. These particular respondents were approached because the author considered their editorial comments about the questionnaire to be an indication of their broad-minded nature, or their skepticism, or both. In any case, these were the kind of particular traits that the author considered to be important.

E. GROUP WORK SESSIONS

The general strategy for gathering facts that was utilized by the author from the outset of this study was developed by J. Whitten, L. Bentley, and V. Barlow, in *Systems Analysis & Design Methods*. This strategy purposely avoided jumping into interviews and group work sessions. Instead, the strategy followed these procedures:

1. Learning all that could be learned from existing documents, forms, reports, files, and books.
2. Observing the system in action.
3. Designing and distributing a questionnaire to clear up issues that were not fully understood.
4. Conducting a group work session to verify and clarify the most difficult issues and problems, once most of the pertinent facts were collected by low-user-methods. [Ref. 1:p. 741]

Personal interviews are recognized as one of the best tools for fact finding. After all, they allow the analyst to collect information from individuals face-to-face. However, there are certain flaws that exist when conducting separate interviews. Separate interviews often lead to conflicting facts, opinions, and priorities. For this reason, a group work session was chosen as a substitute for interviews. [Ref. 1:pp. 735-740]

The purpose of the group work session was to get as many of the end users into one room at the same time and to afford the analyst an opportunity to:

1. Discover additional facts.
2. Verify facts.
3. Clarify ambiguities.
4. Encourage the involvement of the end users.
5. Identify preliminary requirements.
6. Solicit and generate new ideas and opinions. [Ref. 1:p. 735]

In order for the group work session to be successful, the author discovered that solid human relations skills were extremely essential. It was important to be able to motivate the end users to respond freely and openly to the questions, probe for more feedback from the end users, and observe the end users' nonverbal communications.

The author decided that the best forum for the group work session would be to conduct a structured meeting (or round table). With this in mind, a specific set of questions was developed for the "VTC Round Table" to discuss. These questions were open-ended to allow the group to respond in any manner that seemed appropriate.

Once the questions for the VTC Round Table discussion were designed, the members of the VTC Round Table were chosen from those end users who responded to the VTC Users' Analysis Questionnaire in a broad-minded manner and managed to express a certain level of skepticism about the usefulness of VTC. These end users were considered to be the most useful because they had realistic expectations about the possible implementation of a VTC system. The final list of members for the round table was narrowed to limit the number to seven participants.

To prepare for the VTC Round Table discussion, an agenda was developed (see Appendix H) that detailed the who, what, where, why, and how of the discussion and also detailed the specific topics that were going to be covered (complete with time allotments). Once the agenda was complete, it was distributed to all of the participants prior to the discussion. This allowed each member to carefully peruse the various topics and prepare for the discussion.

IV. VTC FEASIBILITY AT NPS

A. SUMMARY OF THE PROBLEMS

Prior to the convening of the VTC Round Table, the author had only a vague idea about the type of problems that stimulated an interest in VTC at NPS. For this reason, the author decided that the main goal of the VTC Round Table discussion would be to clarify these problems so that they could be precisely defined and prioritized.

1. Statement of the Problems

The VTC Round Table thoroughly discussed VTC and deliberated over which problems are most responsive to a VTC solution. The VTC Round Table arrived at a consensus and decided that there are basically two problems that need addressing:

1. NPS is failing to take advantage of the numerous opportunities that VTC technology can deliver. NPS needs to capitalize on these opportunities - particularly those opportunities that save time and money (i.e. travel reductions and the ability to resolve problems quickly) and those that increase command effectiveness (i.e. easy access to experts and the ability to include more people in the decision-making process).

2. NPS can no longer rely exclusively on travelling to meetings as the sole method for conducting face-to-face meetings at dispersed locations.

2. Urgency of the Problems

Research suggests that managers spend anywhere from 30 to 75 percent of their time (2½ to 6 hours a day) engaging in various forms of meetings [Ref. 3:p. 18.1]. Due to the expensive nature of organizational communications, most managers are faced with situations where they must make improvements in their organization's ability to communicate. These improvements are to reduce the operational cost of communicating, while maintaining (or enhancing) the organization's communications abilities. This defines management's communications dilemma: how to accomplish sustained (or enhanced) communications while reducing the costs? There are three external factors that have made these improvements both pragmatic and essential.

1. The new technologies available, making it practical to communicate through teleconferencing.
2. The increasing importance of reducing **information float (lag-time)** and decision making cycles.
3. The rocketing costs of air travel, hotel and motel accommodation, management salaries, and car rentals. [Ref. 35]

Almost one decade ago, the growth of the VTC industry was hampered by the combined effects of the 1982 recession (no economic growth), the *Airline Deregulation Act of 1978* (lower air fares), the lack of a worldwide standard for video compression (lack of compatibility), and the claims of the telecommunications industry that VTC could replace travel (an incorrect assumption) [Ref. 36]. Today the VTC industry has been bolstered by the need to save money at all levels of society, the introduction of the H.261 video compression standard to increase compatibility among VTC users, and a new assertiveness by the telecommunications industry. Now, the VTC industry is attempting to portray VTC as much more than a replacement for travel.

> Teleconferencing provides executives, managers, professional and technical staff with more of the two commodities that are most precious to them: time and communications. Video-teleconferencing is a corporate weapon and an asset, not just a cost displacement. It is more important as a means of increasing productivity than as a substitute for the travel dollar. [Ref. 36:p. 49]

Even though the VTC industry is asserting its position that VTC is not as effective at displacing travel as was previously believed to be true, there are some new and disturbing issues that are beginning to surface in the airline industry. These issues may indeed provide the VTC industry with an external factor that makes travel displacement a valid argument.

In the midst of increased airline competition and heated attempts by the airline industry to lure more customers via massive reductions in airfares, one might conclude that the *Airline Deregulation Act of 1978* has succeeded in lowering fares and making air travel more accessible. However, thirteen years after the landmark bill was signed by President Jimmy Carter, those airline carriers that have survived in this competitive industry are locked in a battle of the weak versus the strong. [Ref. 37]

Representative James L. Oberstar, D-Minnesota, Chairman of the House Public Works Subcommittee on aviation, states:

> In the past year the financial condition of the industry has deteriorated to a point where questions are being raised about the survival of all but three or four carriers. [Ref. 37:p. D-1]

Transportation Secretary Samuel K. Skinner argues that deregulation has been overwhelmingly effective. However, consumer "watchdogs" disagree, saying that the industry is debt ridden and headed for certain oligopoly. The carriers that are expected to survive 1991 are United, American, Delta, and Northwest Airlines. [Ref. 37:p. D-12]

Senator John Danforth, D-Missouri, adds that:

> Deregulation has failed...Three carriers dominating our skies, controlling our airports, and **dictating their prices to consumers** is not what Congress had in mind when it deregulated the airline industry. [Ref. 37]

For those who must contend with travel budgets and the need for increased and improved communications, the deficiencies of the airline industry cannot be seen as good news. Furthermore, the recent increase of discount airfares for business travelers[16] is putting additional pressure on many beleaguered travel managers [Ref. 38].

In an environment where reduced travel budgets are imminent, the latter part of 1991 and beyond does not look very promising for business travel. In fact, government

[16] Most major airlines have announced an increase of approximately 6% (between $20 to $80 more per round trip).

agencies and smaller businesses could be **desperately** seeking alternatives for business travel by early 1992.

B. FEASIBILITY OF THE VTC SOLUTION

Now that the true nature of the existing problems are known, VTC must be analyzed to determine if it is a feasible solution to these problems. The whole purpose of determining the feasibility of a VTC system at NPS is to measure just how beneficial the system would be for the entire organization. In this context, assessment of VTC system feasibility should be an ongoing operation during the entire VTC implementation process.

The VTC Round Table displayed a very progressive stance when it was acknowledged that the most important benefits of VTC are the qualitative benefits (see Table I). Even though the VTC Round Table recognized the **possibility** of limited cost savings due to travel displacement and the apparent instability of the airline industry, it was not convinced that these factors would hold true. Attendees at the VTC Round Table maintained that NPS personnel would continue to travel as usual and that VTC would be used to supplement travel, not replace it. Therefore, it appears that cost savings due to travel displacement are unlikely. For this reason, the VTC Round Table concluded that the operational and technical considerations are the most convincing aspects of VTC, while the economic considerations or cost savings were viewed to be of a secondary magnitude.

1. Operational Feasibility

The operational feasibility of a VTC system would determine how well a VTC solution would work at NPS and how the end users at NPS feel about VTC. In order to solve the problems at NPS, the VTC solution must effectively depict the opportunities that could occur if VTC is implemented at NPS. Additionally, the VTC solution must demonstrate its ability to reduce the strict reliance on travel as the sole method for conducting face-to-face meetings at dispersed locations.

Table I Review of VTC Benefits

VTC BENEFITS

Quantitative

- Displace Travel Costs

Qualitative

- Increase Productivity and Efficiency
  - Reduce Unproductive Travel Time
  - Prevent Meeting delays (VTC participants arrive on time)
  - Reduce Meeting Time (VTC meetings start and stop on schedule)
  - Increase Participation
  - Optimize Attendance
  - Improve Information Exchange (VTC meetings spend more time conducting business and less time with informalities)
  - Decrease Response Time (VTC is "real time" information exchange between point A and point B)
  - Increase Access to Experts
  - Improve Decision Making (VTC allows more of the key decision makers to be involved)
- Improve Management Communications
  - Improve Interface at All Levels
  - Increase Flexibility (easier and less expensive to schedule/cancel VTC meetings)

[Ref. 39]

a. Will VTC Work at NPS?

To assess whether or not a VTC solution would work, the PIECES framework will be utilized. The PIECES framework was developed by James Wetherbe to help analysts classify the nature of certain problems and their solutions. As such, the PIECES framework looks at a problem or a solution in terms of:

1. the need to improve **performance**.
2. the need to improve or control **information**.
3. the need to improve **economics**.
4. the need to improve **control** and security.
5. the need to improve **efficiency** of people and machines.
6. the need to improve **service** to customers and employees. [Ref. 1:pp. 86-87]

(1) Performance

VTC system performance is often cited as the next best thing to being there. This really comes as no surprise in the wake of the recent popularity of VTC.

> Ed Sterbenc, director of product marketing for Tandem Computers in Cupertino, California, used to fly often to Austin, Texas, and Plano, Texas, for meetings with Tandem executives there...These days, Sterbenc and his staff take only a few minutes to go from their Cupertino offices to meetings in Texas. When they walk to a video teleconferencing studio in a nearby building,...it's like crossing a parking lot and stepping into Austin.... [Ref. 40]

In the past, VTC system performance had been extremely limited due to interoperability and interconnectivity problems. These were the main problems that contributed to customer skepticism and delayed the growth of an installed base of VTC users.

Fortunately, the VTC industry, in conjunction with the IXCs and LECs, has responded to these problems and taken measures to resolve them. VTC users can now participate in meetings with a large and expanding base of VTC users regardless of equipment compatibility. VTC gateway services have ensured that VTC users can "meet" with each other until H.261 is fully implemented.

Also, the IXCs and LECs have continued to make improvements in the costs, availability, and reliability of VTC transmission. In fact, the dial-up, switched transmission services have made the process of setting up a video teleconference very simple. VTC users can notify the IXC's or LEC's Network Management Center (NMC) with as little as thirty minutes prior notice (presuming the other parties are ready to video teleconference at the desired time).

The performance characteristics of today's VTC systems make VTC an enticing proposition for NPS. VTC could provide the opportunity for the personnel at NPS to participate in a wide range of VTC meetings with an expanding base of federal government agencies including the DOD and Department of the Navy (DON), plus a large installed base of business and educational users as well. Increased interface with other components of the DOD and DON plus other colleges and universities should be especially beneficial to NPS.

(2) Information

The implementation of a VTC system at NPS would allow for information exchange to occur in a more timely fashion than is currently possible by travel. Information float is reduced with VTC because the time that is required to travel to and from a meeting would no longer be necessary. With VTC, the information float would be reduced to the amount of time that it takes to establish a VTC meeting (normally measured in minutes).

Also, the fact that VTC can accommodate a large number of users helps to reduce the amount of information that needs to be disseminated throughout the organization. Consequently, the amount of redundant information such as memorandums and letters that provide the details of a meeting or seek additional information in response to the meeting would be reduced.

VTC could also provide NPS personnel with improved access to more information than is currently obtained through travel. Whereas travel limits the number of meetings that people can attend in a given day, VTC allows its users to attend several meetings at several locations around the world within the span of a few hours.

Finally, VTC would make it possible for NPS personnel to have access to new types of information exchange such as video classrooms. For a research institution, video classroom training (also known as distance learning) could prove to be extremely profitable because video classrooms will allow educators to "...spread their skills across a much larger population and distance." [Ref. 7:p. 11]

(3) Economy

Economic feasibility will be discussed in more detail later. However, for the purpose of determining operational feasibility, a brief mention of the recent market trends in the VTC industry will be made.

VTC is becoming a more practical method of communicating thanks to the widespread use of less expensive VTC equipment and switched transmission services, plus the increased availability of ISDN. As a result, the future growth of VTC utilization is expected to be quite large and encompass organizations of all sizes.

As Figure 3 demonstrates, market estimates predict that VTC sales will double in FY 1991 and double again in FY 1992, implying that the number of organizations investing in VTC systems will increase rapidly. Figure 3 also indicates that VTC costs are on the decline.

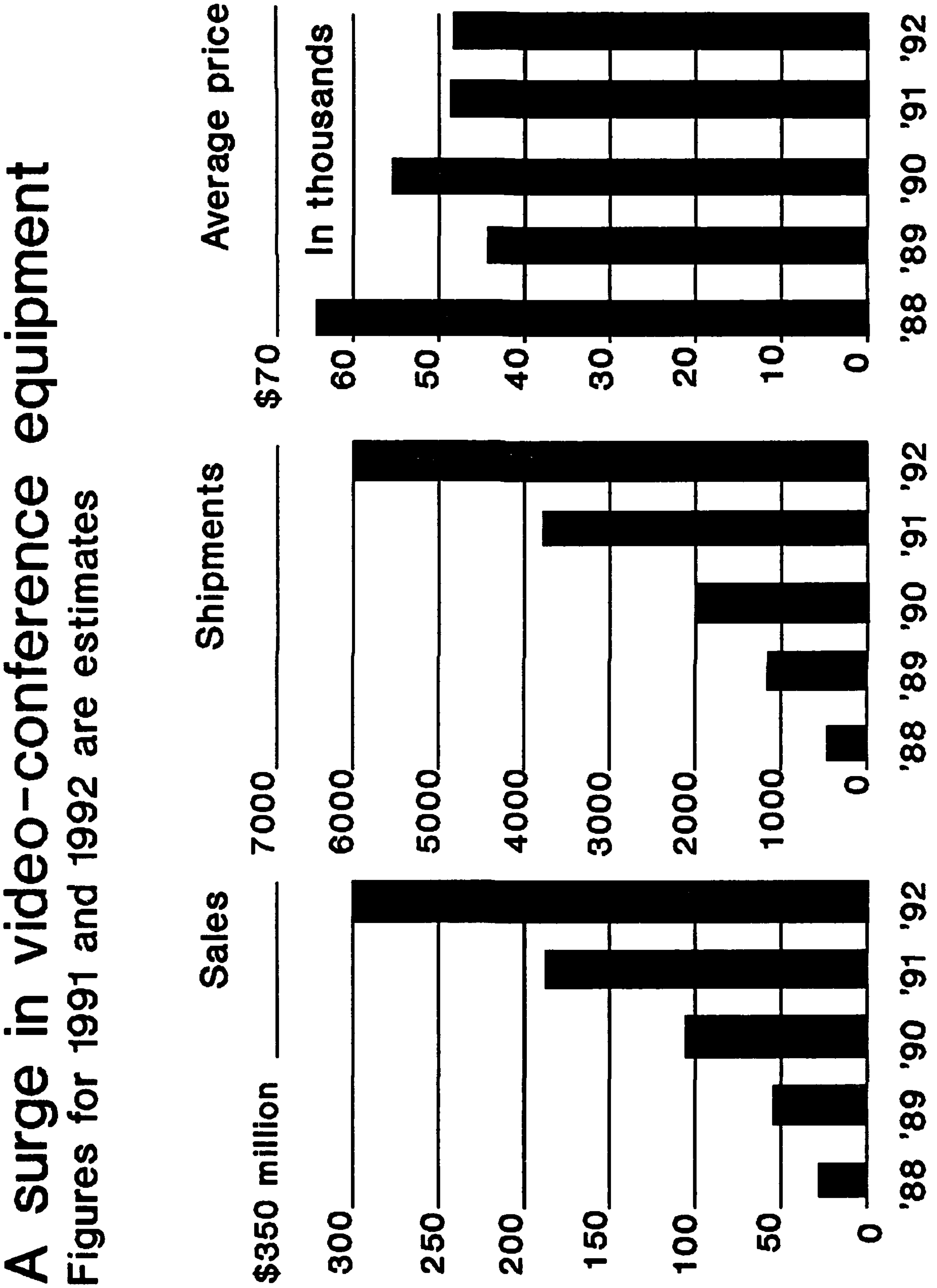

Figure 3 Recent VTC Market Trends [Ref. 40:p. 1E]

The past trends and future predictions indicate that VTC will be less expensive as the installed base of VTC users expands. If this continues, VTC systems are expected to become as popular in the 1990s as the FAX machines were in the 1980s [Ref. 40:p. 1E].

(4) Control and Security

Control and security issues are major concerns at NPS. Fortunately, most VTC equipment manufacturers have developed their systems so that the end users can fulfill both DOD and DON control and security requirements.

As far as controlling the access to a VTC room is concerned, a VTC site manager can ensure that access to the VTC room is limited. By utilizing a system of cipher locks, intrusion sensors, and alarms on any of the VTC room's entrances, the VTC site manager can monitor and allow/deny access to the VTC room.

Additionally, extreme care must be taken to ensure that communications security (COMSEC) is not compromised. Therefore, for those VTC sites with a requirement to transmit classified information (up to and including **TOP SECRET**), COMSEC key material (KEYMAT) and military standard (MILSTANDARD) encryption devices (i.e., KG-94) are available for DOD VTC facilities[17]. [Ref. 41]

If control of compromising electronic emanations (TEMPEST) security is determined to be a requirement (usually determined on a site-by-site basis), the VTC facility can be housed in a 100 dB TEMPEST enclosure that conforms with the Naval Electronic Systems Security Engineering Station (NESSEC) specifications. This particular TEMPEST enclosure will prevent radio frequency (RF) emissions (up to 100 dB) that originate within the enclosure from being monitored on the outside[18]. TEMPEST vulnerability requests should be coordinated with NESSEC and the Naval Investigative Services (NIS) Command[19]. [Ref. 41:pp. 3-6]

Security considerations should also include RF radiation security. If RF radiation security is a problem, RF shielding (which is readily available) might be required for the room and the equipment. In addition, the VTC equipment can also be acoustically treated to ensure that encompassing

[17] VTC on-site managers are responsible for individual access to the encryption devices, the proper keying of the encryption devices, and the operation of all CLASSIFIED video teleconferences. They will also be responsible for verifying that users entering the VTC facility have the proper security clearance.

[18] This is accomplished by utilizing construction materials that will reflect and/or absorb RF emissions.

[19] The Naval Sea Systems Command (NAVSEA) requires all of the network facilities [Naval Ocean Systems Center (NOSC), NSWSES, etc.] on the NAVSEA/AEGIS VTC NETWORK to coordinate with NESSEC and NIS for their TEMPEST vulnerability request.

noise levels do not exceed specified levels. These two measures should be beneficial in preventing the inadvertent disclosure of classified information.

(5) Efficiency

The implementation of VTC at NPS would improve the efficient use of precious resources such as people and time. By maximizing the performance of NPS personnel and improving the efficient use of their time, the overall productivity at NPS would increase.

The most fundamental performance improvement is the opportunity for NPS personnel to remain at home working in their jobs. By displacing travel, NPS personnel could remain on the job more often and reduce the backlog of work that accumulates each day while away on travel. Consequently, a reduction in the backlog of work would afford them with an opportunity to undertake additional projects or participate in more meetings than they currently have time to attend.

Secondly, VTC would allow larger numbers of NPS personnel to participate in meetings than is currently possible by travelling to meetings. The fact that VTC allows more people to attend meetings is the driving force that has allowed improvements in information exchange to transpire.

(6) Services

If a VTC system is implemented at NPS, a wide array of services would be made available to NPS personnel.

Some of these services are hidden within the applications of VTC (see Table II). It just so happens that some of the services that are listed in Table II are also accessible by travelling to meetings, but others are not.

For example, it is not practical for the entire Administrative Sciences faculty to travel to Washington, D.C., for a curriculum development meeting. There are simply too many time and money constraints that prevent the entire faculty from attending. Additionally, the Administrative Science curriculum cannot afford to spare large numbers of its faculty for two or three days while a curriculum development meeting takes place.

VTC, on the other hand, can accommodate a large portion of the Administrative Sciences faculty members. Why? Because curriculum development meetings via VTC are shorter, more direct, and allow for more people to participate[20]. Studies show that participants in a video teleconference

[20] Some VTC facilities can accommodate over 100 people, but most have seating capacity for only 20 to 30 people.

Table II VTC Applications / Services

VTC APPLICATIONS
Management/Administrative
Budget Reviews
Executive Conferences
Management Development
Personnel Matters
Planning Meetings
Project Management
Strategy Sessions
Training Sessions
Engineering
Project Coordination
Staff Engineering Sessions
Miscellaneous Services
Professional Development Seminars
Project Coordination
Equipment Trouble-Shooting
Public Relations
Educational Offerings
Video Classroom
Professional Seminars
Lecture Series

[Ref. 42]

arrive on time more frequently, are better prepared to conduct their business, and avoid trivial conversation more than they do when travelling to meetings. This is because they have a perception that VTC is expensive and they do not want to waste time and money. The end result is high quality decisions being arrived at in a more timely fashion. [Ref. 43]

As far as availability and reliability are concerned, most of the IXCs and LECs guarantee the availability of their services within a range of 95 - 99.7 percent of the time and promise error-free transmission time (measured in seconds) as high as 95 percent of the time. These figures will vary depending on the IXC or LEC. [Ref. 33:pp. 38 and 49]

Additionally, most IXCs and LECs offer enhanced services for their customers. For example, gateway services (mentioned earlier) are becoming a standard feature of most VTC transmission facilities. Also, there are newer services that are beginning to emerge such as "bandwidth on demand," which gives VTC users the option of requesting additional amounts of bandwidth if the need for higher picture quality is greater than the need for reduced cost.

b. How do the End-Users Feel?

During the VTC Round Table discussion, an attempt was made to clarify the official positions of the VTC end users (namely the administrative staff and the faculty department chairmen). Sentiments that were expressed concerning VTC implementation ranged from enthusiastic to hesitant.

The administrative staff at NPS has a strong conviction that VTC will enable it to take advantage of new opportunities that are possible with this technology. As a result, the administrative staff is extremely supportive of VTC implementation at NPS.

Meanwhile, the faculty department chairmen have been somewhat reluctant to show their support for VTC. They have misinterpreted the possible implementation of VTC as an effort by the NPS administrative staff to eliminate or drastically reduce their travel budgets.

During the VTC Round Table discussion, the faculty members who were present appeared relieved when they learned that this assumption about VTC was incorrect. In fact, the Space Systems Academic Group Chairman claimed that he would definitely support the implementation of VTC if it was packaged as an attempt to enhance productivity rather than an attempt to replace travel. He also had a strong belief that the majority of the faculty department chairmen would support this notion as well (based on his association with a number of his colleagues).

2. Technical Feasibility

This discussion on the technical feasibility of VTC will center on what is practical and reasonable. Therefore, the technical feasibility of VTC at NPS will address these two important issues:

1. Is VTC practical?
2. Does NPS need help in making VTC work? [Ref. 1:p. 773]

a. *Is VTC Practical?*

Most organizations like to play it safe when they are about to make a large money investment in a new technology. As a result, most organizations prefer to invest in proven or "mature" technologies rather than emerging or "state-of-the-art" technologies. In today's era of D^3, it should not be too big of a surprise that NPS chooses to play it safe rather than take any undue risks.

The VTC industry is one of the fastest growing technological industries in the world. In fact, *Fortune Magazine's 1991 Investor's Guide* cites VTC as one of the most promising markets of the 1990s [Ref. 44].

VTC usage via dedicated networks has increased dramatically over the past two years. But the real news concerning VTC usage is the recent availability of affordable switched services for VTC transmission. Now more than ever, VTC is becoming inviting, not only to those users who wish to add newer sites to already existing VTC networks, but also to those new users who do not currently possess a private VTC network. [Ref. 21:p. 35]

Figure 4 illustrates how the use of VTC is expected to increase with time. Current events have sparked a wave of increased VTC investment in both the public and private sectors. As a result, it is prudent to say that use of VTC technology is starting to peak, indicating that VTC

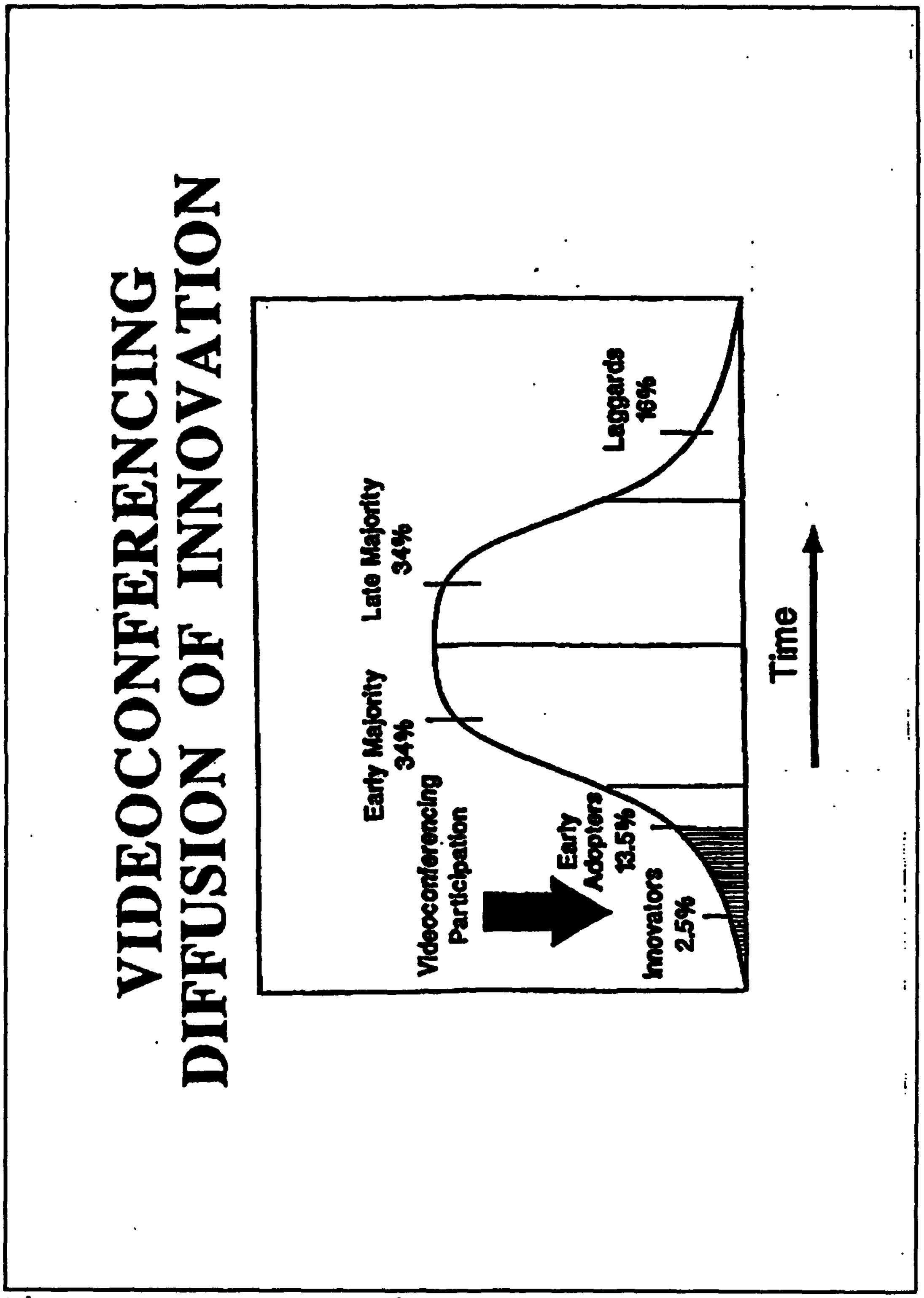

Figure 4 VTC Usage vs. Time [Ref. 45]

people who are responsible for VTC at NPS. For example, the ITCA publishes an annual compilation of VTC facilities that are located throughout the world. For each VTC facility, the listing includes the name of the VTC manager, his/her telephone number, the CODEC designation, the transmission speed, and the name of the VTC network. This kind of information would be very useful for a VTC manager who needs to know if a particular organization in the United States or from another country has access to a VTC facility.

C. CONCLUSION

From an operational viewpoint, the PIECES analysis of the VTC solution at NPS demonstrated that the implementation of a VTC system could provide desirable and reliable services for NPS. These services could enhance the quality of work at NPS and increase the efficiency and productivity of NPS personnel. At a time when the DOD is stressing Total Quality Management (TQM), VTC offers the vehicle for NPS to meet its future needs through quality improvements.

Also, when the members of the VTC Round Table had an opportunity to review the VTC applications and services (as shown in Table II), they all acknowledged that VTC is a proven technology that should be exploited at NPS. The members of the administrative staff and faculty department chairmen who attended the VTC Round Table were convinced that the applications of VTC would be beneficial for their jobs.

From a technical viewpoint, VTC technology is still evolving at a rapid pace, but standardization efforts by the CCITT and VTC equipment manufacturers have done much to provide stability in the VTC market. Measures such as the H.261 video compression algorithm and the flexible architectures of the VTC hardware have served to eliminate most of the problems that have existed in the VTC industry such as interoperability and equipment obsolescence.

Given the operational and technical analysis of VTC at NPS, the author concludes that **VTC technology is a feasible solution to the problems at NPS.** Specifically:

1. It will allow NPS to conduct its business in a more efficient and productive manner.
2. It is well received by the initial end users.
3. It is a mature and readily available technology.
4. There is sufficient professional guidance to facilitate the implementation of VTC at NPS.

The implementation of VTC will allow NPS to participate in new and innovative developments in education such as video classrooms. As a research institution, this is conceivably the most important factor that makes VTC an inviting proposition. In addition, VTC implementation can provide an opportunity to overcome the negative external factors that have forced NPS to conduct its business with less time and money, such as D^3.

V. VTC FEASIBILITY STUDY RECOMMENDATIONS

Now that the feasibility of VTC system implementation has been established, the next logical progression is to issue a series of recommendations on how to make it happen. Before these recommendations are made, however, the parameters that confine the project need to be specified.

A. VTC SYSTEM IMPLEMENTATION PARAMETERS

One of the objectives of the VTC Round Table Discussion was to determine the end users' general expectations about how VTC implementation should be achieved. After a brief debate among the various members, the VTC Round Table generated some general ideas on how the VTC system implementation should proceed. This proposal maintained that:

1. Every effort should be made to ensure that the performance of a particular VTC system is measured before a large sum of money is obligated for that system. In fact, every effort should be made to lease first, with an option to buy.

2. Caution should be used when determining what kind of VTC system to lease (with an option to buy) and which type of VTC network to choose.

3. The VTC system that is selected should rely heavily on standards to offer maximum interoperability and interconnectivity with other VTC users.

4. The VTC network that is selected should offer maximum interface with other VTC users.

5. NPS would like to have an operational VTC capability by the middle of FY 1992.

6. The Director of Students and Programs (Code 03) and the Dean of Information and Computer Services (Code 05) have agreed to act as the focal point for VTC implementation until an ad hoc committee can be developed.

B. IMMEDIATE ACTIONS

Given these operating parameters, the author recommends that NPS achieve three specific actions. These actions include:

1. The creation of a VTC Steering Committee (VSC) to provide guidance and direction for the VTC system implementation.

2. The implementation of the FTS2000 CVTS to satisfy the VTC requirements at NPS.

3. The employment of a full-time VTC manager to assist the VSC and to operate and maintain the VTC system, once it is installed and becomes operational.

1. Creation of the NPS VTC Steering Committee (VSC)

The creation of the NPS VSC will have a two-fold effect on the implementation of VTC at NPS. First of all, it will signify (to the remainder of the NPS organization) that VTC is about to become a reality at NPS. Second, it will help to ensure that a complete and usable VTC system is ready to meet the needs of NPS.

The major responsibilities of the VSC members will be to determine VTC requirements (to the extent that they were not already determined during this study) and act as a point of contact during the implementation process. Additionally, the VSC will:

1. Coordinate the requested requirements with the respective higher management levels.

2. Ensure that identified requirements match system capability.

3. Develop a plan of action and milestones (POA&M).

4. Coordinate all efforts through the VSC chairman with other interested parties.

If the VSC is furnished with the essential manpower and fiscal resources to do its job, the VSC will become the major focal point for the coordination of all VTC implementation efforts at NPS. However, in order for this to succeed, the VSC leadership must have a solid reputation and adequate experience in systems analysis and design methods. Therefore, the author recommends that the Director of Students and Programs (Code 03) and the Dean of Computer and Information Services (Code 05), act as the initial leadership for the VSC until a formal chairman has been selected and designated.

2. Implementation of FTS2000 CVTS

As with the other FTS2000 service offerings, FTS2000 CVTS is currently available on Network A (AT&T) and Network B (U.S. Sprint) - see Appendix F for more details.

The DON has been assigned to Network A of the FTS2000, along with the remainder of DOD. As part of the FTS2000 CVTS service, AT&T will provide CLI's low-bandwidth Rembrandt 56

CODEC, a multiplexer, and transmission services at 384 kbps over AT&T's FTS2000 fiber optic network[21]. AT&T also includes, at no extra charge, other valuable services such as easy VTC scheduling and CODEC-to-CODEC network management by AT&T's FTS2000 Network Control Center (NCC). Future plans will include a digital gateway service for easy access to other VTC networks (including FTS2000 Network B , U.S. Sprint's *The Meeting Channel*, and other VTC networks), and a CODEC upgrade to CLI's Rembrandt II/VP. The CVTS is charged on a usage basis which includes a monthly fee for use of the VTC equipment. [Ref. 46] Here is an additional overview of FTS2000 Network A CVTS (as provided by the GSA):

> FTS2000 Network A Compressed Video Transmission Services is provisioned over dedicated terrestrial access facilities. This mode is used primarily for point-to-point, two-way video teleconferencing, but also supports scheduled, one-way, point-to-point and point-to-multipoint broadcast with audio return. A full-duplex interactive system can carry graphic, audio, and data information.
> FTS2000 is provided with a video CODEC which provides the principal interface...for video, audio, graphic, data and control signals. The video CODEC performs digitization, compression, and time division multiplexing (TDM) of full-motion video, graphics, audio and user data interfaces into a single data stream for transmission over the network. The vendor supplied CODEC is a CLI Rembrandt which provides service for Network A users at the transmission speed of 384 kbps. [Ref. 47]

a. FTS2000 CVTS Advantages

Due to Public Law that requires mandatory use of FTS2000 by all government agencies, there are a growing number

[21] VTC equipment is not included.

of federal government agencies that are subscribing to the FTS2000 CVTS. The Environmental Protection Agency (EPA) and the GSA are two of those agencies that have been utilizing FTS2000 CVTS for almost a year.

Earnest M. Stevens, Chief of Space, Mail and Telecommunications for the GSA, had the overall responsibility for implementing FTS2000 CVTS within the GSA. He has acknowledged the following advantages as being the primary reasons that the GSA decided to subscribe to the FTS2000 CVTS:

> First, because the FTS2000 contract is already approved, we **didn't have to go through a lengthy procurement process.** And second, CVTS allows us to **avoid making a major capital commitment until we have seen the benefits** of videoconferencing first-hand. [Ref. 46:p. 5]

These two advantages are the primary reason that the author strongly recommends the use of FTS2000 CVTS by NPS. The implementation of FTS2000 CVTS will allow NPS to take advantage of AT&T's CODEC-to-CODEC service for its FTS2000 CVTS subscribers. This "cradle-to-grave" service includes:

1. Technical consultation and support before, during, and after service is installed by AT&T.
2. One number to call (1-800-288-3000) to set up the video teleconference. AT&T does the rest.
3. With as little as 15 minutes advanced notice, AT&T's NCC will bring the systems on-line and test the connection to ensure that all systems are operating. All of this occurs before the video teleconference begins.
4. One number to call (1-800-633-6384) for trouble reporting and resolution.
5. Training for designated VTC managers. [Ref. 47]

These services are advantageous for NPS because AT&T will provide them at no extra cost. Other VTC users on dedicated networks have to pay a substantial fee for these types of services. [Ref. 48]

If these services are not enough to justify the author's recommendation, AT&T also has plans to provide a digital gateway service (again at no extra charge) in the near future. As part of this service, it will eventually be possible for NPS to interface with FTS2000 Network B, AT&T's Defense Commercial Telecommunications Network (DCTN) and U.S. Sprint's *The Meeting Channel* (just to name a few). This service will also interface with a future (yet to be named) university and collegiate network that is currently in the developmental stages. This gateway service will allow NPS to achieve its desired goal of maximum interface with as many VTC users as possible. It will also provide NPS with an outlet to share in video classrooms with other distinguished universities via the future university and collegiate network. [Ref. 24]

In a final attempt to justify the author's recommendation, NPS should subscribe to the FTS2000 because the federal government has mandated (by public law) that all federal government agencies (including the DOD and DON) will make the transition to FTS2000, unless an exemption can be made under the terms of the Warner Amendment. It is not very likely that NPS can successfully plead a case for having a C^2 requirement. Therefore, FTS2000 is the logical choice.

b. FTS2000 CVTS Costs

The next step is to determine how much it will cost NPS to implement FTS2000 CVTS. At this point, an estimation of the developmental and operational costs for FTS2000 CVTS will be made. The author (based on discussions with VTC managers at several locations) estimates that it will take one and a half years to fully implement VTC at NPS.

Please keep in mind that numerous options are available for NPS in determining what the final costs will actually be. For this reason, all optional costs will be highlighted to identify them as such. Also, when it becomes necessary to narrow a particular cost down to a low or a high dollar figure, this study will select the higher dollar figure[22].

(1) Developmental Costs

VTC system developmental costs are normally one-time costs that do not recur. Most VTC system developmental costs are evaluated in terms of:

1. Personnel costs - the salaries of analysts, consultants, VTC on-site managers, secretaries who work on the project.

[22] The author believes that it is better to err on the side of higher cost estimates than to err on the side of lower cost estimates. It would be a critical mistake to "paint a rosy picture" of VTC system development for the decision makers at NPS.

2. Promotions and training costs - the costs of making the end users aware of VTC technology and applications plus training them to operate the system.

3. VTC equipment costs. [Ref. 1:p. 775]

The developmental costs for FTS2000 CVTS implementation that are shown in Table III were derived from the dollar assessments provided by Debbie Walsh (VTC Manager at Fort Ord in Monterey, California), Telemanagement Resources International, Incorporated (TRI) and *Network World*. Ms. Walsh is cognizant of the issues that currently face VTC managers. TRI is a teleconferencing consulting firm with documented experience in providing effective telecommunications guidance for a large number of business, educational, and government customers. *Network World* is a weekly publication that is distributed to assist managers and professionals in their efforts to maintain communications equipment and systems, including voice, data, and video. The author considers the dollar figures that these sources have provided for this study to be highly reliable.

Personnel Costs:

A professional, on-site, VTC manager will need to be hired to facilitate the organization's transition to the VTC technology. An on-site VTC manager is a telecommunications professional who is knowledgeable about every aspect of VTC from top to bottom. This individual will be responsible for the entire VTC system project (from beginning to end), as well as the day-to-day operation of the VTC system (once it becomes functional). Ms. Walsh estimates that the average salary for a VTC manager is approximately $40,000 dollars per year[23], depending on the level of experience [Ref. 49].

The personnel costs for VTC system project management will also include the salaries of assistant manager(s) who are hired to support the on-site VTC manager. These assistant manager(s) will perform the rudimentary tasks of managing the VTC system project and conferring with representatives in the organization that are involved in the project. TRI cites the typical cost of complete responsibility for VTC system project management (i.e. any assistance that the on-site VTC manager may need in managing the project) to be approximately $9,500 to $57,500 per design (based on the complexity of the tasks). This study will use the higher of the two dollar figures ($57,500) for our estimate of VTC system project costs. [Ref. 50]

In some situations, there are organizations that lack a satisfactory number of professionals to work full-time on VTC system implementation. To alleviate this problem, most organizations prefer to hire a professional consultant to develop their VTC system design and to prepare the bid

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[23] Remember that Table III dollar figures are based on a one and a half year timeline for VTC system development. Therefore, Table III reflects $60,000 for the cost of a VTC on-site manager.

Table III Estimated Costs of FTS2000 CVTS Implementation

DEVELOPMENTAL COSTS (1½ YEAR SCHEDULE):	
Personnel:	
1 VTC on-site manager ($40,000/year x 1½ years)	$60,000
Assistant Manager(s)	57,500
1 Consultant (optional)	15,000
Training:	
Promotions (optional)	10,605
User Training (optional)	3,800
Equipment:	
Room equipment (optional if leased)	20,000
CODEC (optional if leased)	19,345
Total (including all optional costs)	$186,250
Total (excluding all optional cost)	$117,500
OPERATIONAL COSTS (per year):	
Annual Fixed Costs:	
Personnel:	
VTC on-site manager	40,000
VTC System Usage:	
Video Service (transmit and receive)	9,600
Encryption readiness	300
VTC System Maintenance:	
Maintenance contract (optional)*	7,000
Total (including optional costs)	$56,900
Total (excluding optional costs)	$49,900
Annual Fixed Costs of Leasing (optional if equipment is purchased):	
Equipment:	
Room equipment (including CODEC)**	39,840
Low-bandwidth CODEC (only)	11,400

* spare parts included
** includes end-to-end service maintenance

Table III (Continued)

OPERATIONAL COSTS (Continued):	
Annual Variable Costs:	
VTC System Usage (1008 hours/year):	
San Francisco to Washington D.C ($139/hour)	$140,112
Conference establishment ($15/per location) for each one hour video teleconference ($30 x 1008)	30,240
Total	$170,352

specifications and evaluation criteria. The employment of a consultant is optional, but there are many advantages in doing this; primarily that consultants have vast experience in dealing with the problems that hamper VTC system development. A good consultant can spot trouble immediately, take corrective action, and save valuable time and money, while preventing errors and schedule delays. TRI cites the typical cost of a VTC consultant to develop VTC system design to be approximately $15,000 per design (remember that this cost is optional) [Ref. 51].

Promotions and Training Support:

Promotions planning is optional, but it is also an integral part of VTC system development. Promoting the VTC system will go a long way in assisting the end users to become knowledgeable in VTC technology and its applications.

Carefully selected promotional material will help to enhance any VTC system. [Ref. 52]

TRI estimates that competitive pricing for promotional materials will range in the neighborhood of $10,605. This cost will cover such items as user's guides, evaluation forms, and videotapes. [Ref.52: p. 2]

User training is optional, but most professionals view training as a crucial element of VTC system development. After all, if the end users do not know how to properly use the VTC system (i.e., work the control panel for the lights, cameras, and audio) or if the VTC manager does not know how to properly operate and maintain the VTC system, the system will be doomed. Most of this training is provided by the VTC equipment vendors at no additional cost.

> Typically, equipment vendors and room integrators offer excellent maintenance training and a basic room facilitator course, emphasizing system operation. [Ref. 52:p. 2]

If this training is not sufficient or satisfactory, user training for VTC managers and end users may be obtained from consultants and equipment vendors. TRI believes that $1900 is a reasonable price to pay for each of these types of training courses ($3800 for both courses) [Ref. 52:p. 3].

Equipment Costs:

NPS has shown a keen interest in establishing a "full-feature" VTC system in the new academic building, currently under construction. Since a potential room is already under construction, the only relevant cost for a "full-feature" VTC room will be the cost of the VTC equipment.

It is very difficult to specify the equipment costs for a VTC system without first knowing which vendor has been selected to provide the equipment (vendor selection will not be made at this stage of the VTC implementation process). Fortunately for this study, an article published in the July 1, 1991, issue of *Network World* ("Fine-tuning the Video Conference" by Salvatore Salamone) provides cost estimates for VTC equipment.

Salvatore Salamone estimates that the equipment for a "full-feature" VTC room (cameras, televisions, microphones, and other ancillary equipment) will vary from $15,000 to $20,000 [Ref. 53]. This study prefers the higher dollar figure ($20,000) for the cost estimate.

The CODEC (as mentioned earlier) is the most essential (and expensive) component of a VTC system. After all, the CODEC is the component that makes economical and efficient VTC possible. The average CODEC, which is normally provided as a separate feature, has an estimated cost of $19,345 in 1992 [Ref. 54].

(2) Operational Costs

The cost of operating the VTC system on FTS2000 CVTS can be further classified into one-time costs, fixed costs and variable costs components. One-time costs are self-explanatory. Fixed costs occur on a regular basis and are usually stable (or unchanging) in the long term. Variable costs, on the other hand, occur as the result of some usage factor and vary by the amount of usage.

The majority of the dollar figures that are presented in this section have been provided by the GSA, who oversees the FTS2000 CVTS, and Ms. Debbie Walsh. These figures are **only** approximations of what it could possibly cost NPS to operate a VTC system on FTS2000 CVTS. However, the author considers these figures to be **very** good approximations.

One-Time Costs:

AT&T charges a service initiation fee of $2500. This charge is for the establishment of the FTS2000 CVTS service on Network A. [Ref. 55]

Annual Fixed Costs:

The annual fixed costs for most VTC systems are normally specified in terms of:

1. Personnel cost - the annual salary of a VTC manager who operates and maintains the VTC system.

2. VTC system usage - the cost for circuit availability, video service, and encryption support.

3. VTC system maintenance costs - the cost of routine and corrective maintenance including the supply of spare parts.

Most organizations realize that someone is needed to manage the daily operation and maintenance of their VTC system because VTC system management is a full-time job, not some collateral position. As previously mentioned, the average salary of a VTC manager is approximately $40,000 per year.

Under the provisions of the FTS2000 Network A CVTS, AT&Ts charges an annual fee of $9,600 for the transmission and reception of VTC signals. This service incorporates CODEC-to-CODEC repair of the system, including preventive and corrective maintenance. There is also an additional charge of $300 for encryption readiness, which is optional for NPS (but recommended). [Ref. 55:p. 4]

A maintenance contract for the VTC equipment (equipment other than the CODEC) entails an additional charge for preventive and corrective maintenance. Fort Ord's VTC system, which is part of the DCTN, is currently paying a maintenance fee of approximately $7,000 per year for the preventive and corrective maintenance of its VTC equipment. This charge (which is optional) is typical of general maintenance contracts for VTC systems. [Ref. 56]

NPS needs to determine whether or not a maintenance contract is truly necessary, beyond the contract for spare parts support. The author contends that NPS could rely on NPS personnel to perform the preventive maintenance, once they are properly trained on the VTC system. However, the corrective maintenance should be accomplished under the terms of the manufacturer's maintenance contract (due to warranty issues that normally stipulate who can perform the corrective maintenance and who cannot).

Annual Fixed Cost of Leasing:

During the VTC Round Table discussion, there was considerable discussion concerning the "lease-or-buy" options for a VTC system. As a result, Table III also lists the operational cost of a VTC system in terms of what it would cost to lease the VTC equipment and CODEC.

The FTS2000 CVTS provides one CLI Rembrandt 56 CODEC (384 kbps). The annual charge of the Rembrandt 56 CODEC is $11,400 per year (which includes preventive and corrective maintenance). [Ref. 55:p. 4]

Even though the DON is not assigned to U.S. Sprint's FTS2000 Network B, U.S. Sprint provides a good example of a lease option for VTC equipment (which includes a CODEC). The annual costs of leasing the VTC equipment is $39,840 per year (which includes preventive and corrective maintenance). [Ref. 57]

On a final note, if the decision is made to lease the VTC equipment, the developmental costs would be substantially less. This is because the one-time purchase cost of the VTC equipment would be eliminated (assuming that the equipment would not be purchased in the future).

Annual Variable Costs:

Variable costs for VTC systems can be classified in terms of the hourly VTC system usage for:

1. Network transport of VTC signals per leg (time-of-day and volume sensitive).
2. Originating access by the calling party (time-of-day and volume sensitive).
3. Terminating access. The calling party pays for the receiving end's access to the network (time-of-day and volume sensitive).
4. Conference establishment. One charge per location. [Ref. 55:p. 4]

Before an estimation of variable cost can be made, some estimate of the annual VTC usage at NPS must be determined. There is no possible way for the author to accurately estimate what the VTC system usage at NPS would be. Therefore, the author has decided to use the GSA's estimate of typical VTC system usage.

The GSA uses an approximation of 21 hours of VTC system usage per week [Ref. 55:p. 3]. Naturally, there would be some weeks that experience more usage than 21 hours, while other weeks would see the usage drop considerably. The main purpose here is to show what VTC system variable cost will be at a given amount of VTC usage. Twenty-one hours per week translates to an annual VTC system usage of 1008 hours.

AT&T realizes that it is difficult to estimate the variable costs of VTC when the network transport, the originating access, and the terminating access charges are sensitive to variances in the time-of-day and the total volume of business that is generated (monthly). The variable charge for using the FTS2000 CVTS would be either more or less, depending on the time of day. At the same time, the variable charge would be less when the total number of hours that the FTS2000 CVTS is used increases.

For this reason, AT&T has used levelized costs (or cost averaging) to arrive at their annual variable costs of VTC. Based on 1008 hours of VTC usage annually (21 hours per week), AT&T has determined that the annual variable charge of VTC from San Francisco to Washington, D.C., will be $140,112 (or $2,919 per week). [Ref. 55:p. 3]

The final variable charge is a conference establishment charge of $15 per location for each video teleconference ($30 for each point-to-point video teleconference) [Ref. 55:p. 4]. If NPS conducts 1008 one hour video teleconferences each year, AT&T will charge an annual variable charge of $30,240 for conference establishment.

FTS2000 CVTS Costs Overview:

The developmental costs for FTS2000 CVTS implementation would vary depending on whether or not the VTC equipment is purchased or leased (please refer to Table III). On one hand, if the VTC equipment is purchased, the developmental cost would range anywhere from $156,845 to $186,250 (the higher figure includes the optional costs, while the lower figure does not). On the other hand, if the VTC equipment was leased, the developmental costs would range from $117,500 to $146,905.

The operational costs would also vary, depending on whether or not the VTC equipment is leased or purchased. If the VTC equipment is purchased, the operational costs would range from $220,252 to $227,252 per year (once again, accounting for the optional cost). However, if the VTC equipment is leased, the operational costs would range from $260,092 to $267,092 per year. If the CODEC (only) is leased, the operational cost would range from $231,652 to $238,652. Please remember, the operational costs are based on 1008 hours of VTC system use per year.

At first, the developmental and operational costs of FTS2000 CVTS implementation appear to be excessive. But a quick glance at the travel budget at NPS indicates that this may not be a certainty.

In FY 1990, NPS was authorized $2,569,914 for travel. Of that amount, NPS obligated $2,130,731.25 (83 percent), leaving $439,182.75 as unobligated travel funds. [Ref. 58] If Forrester Research, Incorporated (a harsh critic of VTC's cost effectiveness) is correct in its assertion that VTC technology can only save 20 percent of all travel costs, then most would agree that travel displacement is insignificant [Ref. 21:p. 26]. However, even if this statement is assumed to be true, **NPS could reduce its travel**

obligation by $426,146.25, which is a very significant reduction.

In addition, if the estimated savings from 20 percent of travel displacement is combined with the amount of unobligated travel funds, a total of $865,329 could be redirected towards paying the costs of FTS2000 Network A CVTS implementation. However, it is unlikely that the managerial error that allowed $439,182.75 of unobligated travel funds will be repeated. Nevertheless, the author maintains that some level of economic justification can be inferred.

3. Employment of a Full-Time VTC Manager

Even though the salary of a qualified VTC manager is approximately $40,000 per year, the benefits of having a permanent manager who is trusted with every detail of the VTC facility and its operation is well worth the salary that is paid. The operation and maintenance of a VTC facility is just too difficult and time consuming for an individual to perform as a collateral duty. For these reasons, the author highly recommends that a quality VTC manager be employed at NPS.

C. FOLLOW-ON ACTIONS TO THE VTC FEASIBILITY STUDY

Figure 5 illustrates the VTC implementation process and details the tasks that should be followed in the wake of the VTC feasibility study. There are three follow-on phases of VTC implementation: research and design (R&D), procurement and implementation, and operations. These are the steps that

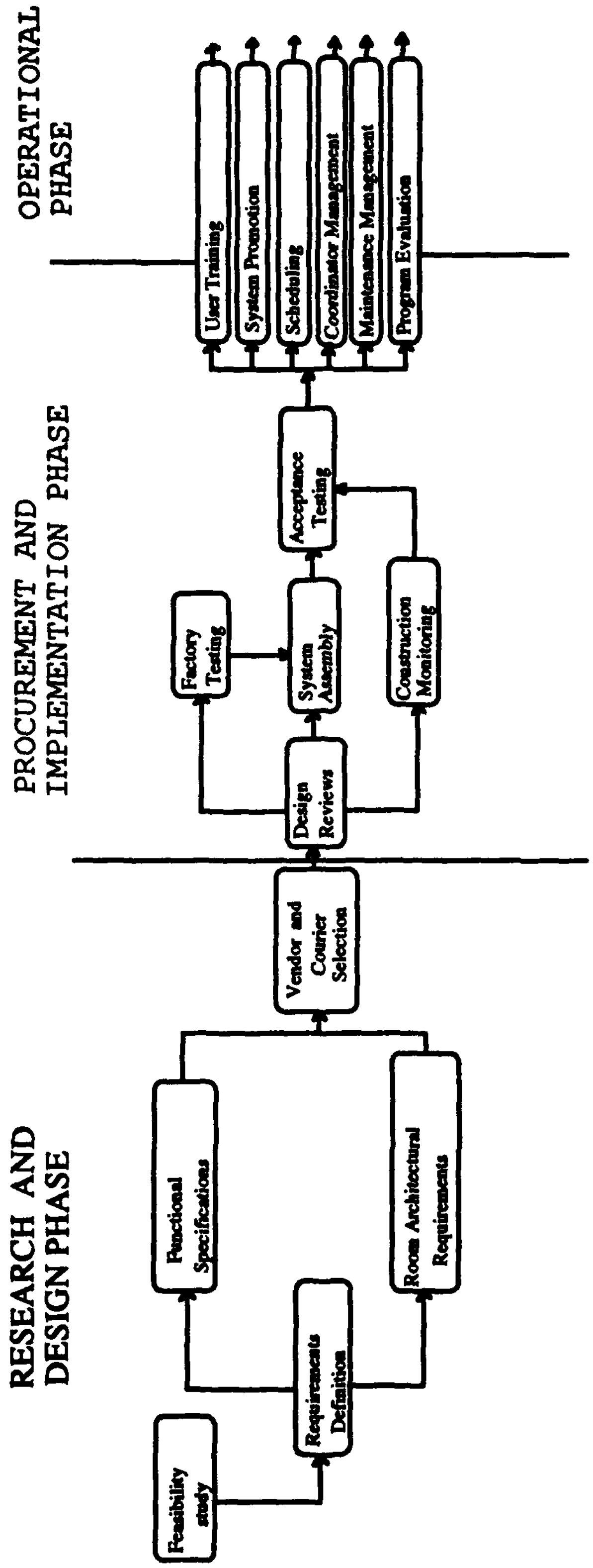

Figure 5 VTC Implementation Process [Ref. 5:p. 12]

should be utilized to execute the author's recommendations. Unless otherwise stated, the descriptions of the three phases of the VTC Implementation process were derived from Robert Keiper's *VTC Implementer's Guide*. [Ref. 5:p. 11-26]

1. Phase One: Research and Design (R&D)

The first phase of the VTC system implementation process is the most crucial. Careful attention to research and design can ensure that the transition into the subsequent phases will progress smoothly and that the VTC system is one that the organization will use.

a. Requirements Definition

Once the feasibility study has received the approval of top-level decision makers, funding is usually provided to develop a requirements definition for a VTC system. The requirements definition includes a concept of operation for the VTC system that details the operations, required staffing, training, maintenance requirements, and maintenance support required for the VTC system.

> The source of successful VTC design is hidden in the needs of the prospective users. To the extent that these questions were not fully answered during the research done during the feasibility study, now (during the development of the requirements definition) is the time to discover the answer to all issues related to VTC user requirements. [Ref. 5:p. 15]

b. Functional Specifications

When the VTC implementation is nearing full-project approval, three procurement tasks lay ahead. Procurement of the VTC system and the communication links plus the construction[24] of a VTC room (in a space that is provided by NPS) is initiated by submitting Request for Proposals (RFPs) to private contractors for each procurement. [Ref. 5:p. 21]

Functional specifications can be extremely helpful in the preparation of an RFP. Functional specifications describe the performance guidelines and VTC system features that contractors must provide in order to fulfill the contract. The functional specifications must be detailed enough to ensure that the delivered VTC system, communication links, and the VTC room meet the user requirements and guarantee overall system performance. Some of the most important areas on which to concentrate are standardization, interoperability, interconnectivity, and security.

c. Architectural Requirements and Room Design

In conjunction with the development of the functional specifications, the VTC architectural requirements are determined. Room surveys are conducted and requirements are defined to ensure that the VTC room meets the desired electrical, acoustical, lighting, and ventilation characteristics. [Ref. 5:p. 22]

VTC room design is a product of the requirements definition, functional specifications, and architectural

[24] Construction delineates the TEMPEST work, lighting, wiring, carpet laying, table installation, etc., that must be done.

requirements. Normally, VTC rooms are designed to support the following:

1. Informational (formal) briefings.
2. Informal information exchange.
3. Project/program updates.
4. Staff updates.
5. Emergency meetings.
6. Information from field locations.
7. Formal program reviews (multi-location conferences).
8. Contract negotiations. [Ref. 5:p. 15]

Various room designs are available to support these missions, but each individual VTC application should be carefully studied before room design alternatives are selected.

2. Phase Two: Procurement and Implementation

After the VTC system contract has been awarded, the contractors will begin to deliver and install the VTC system and a program manager will be tasked to monitor implementation. Consistent with the systematic construction of the system, the testing of individual system modules (for quality assurance), plus supervision of the construction process and periodic design reviews may be necessary to ensure that the constructed design matches the specifications. [Ref. 5:p. 24]

Once the VTC system construction is complete, the contractor will demonstrate the system to ensure that it meets the test specifications that were agreed upon during the awarding of the contract. Normally, the testing will be conducted by a contracted testing facility, other than the contractor who delivered and installed the system, or an internal testing facility within the organization. [Ref. 5:pp. 24-25]

3. Phase Three: Operations

Even as the VTC system implementation draws to a close, final preparations that will facilitate the organization's willingness to use the system must be made. The initiation of a series of activities that increase the organization's awareness of the system as well as defining certain policies and procedures can be beneficial. For example, the command could require that all requests for travel specify the reason why the travel could not be displaced by VTC. By taking this step, the command can ensure that the VTC system is properly utilized.

Proper user training can guarantee that the VTC system users have sufficient "hands-on" training. This can ensure that they are familiar and comfortable with the operation of the user-VTC system interface. [Ref. 5:p. 25]

System promotion will highlight to the organization that a new and important communications tool is available for its use. Fliers, plan-of-the-day (POD) notes, *Quarterdeck* articles, and ribbon-cutting ceremonies can help to strengthen the prospective VTC users' desire to utilize the VTC system. [Ref. 5:p. 25]

A reservation system for the usage of the VTC system must be developed to ensure its timely and efficient use. The VTC reservation system must be properly controlled to ensure accurate allocation of the available time slots, but still be flexible enough for emergency access. [Ref. 5:p. 25]

The employment of a well qualified VTC system coordinator to provide for the day-to-day operational support in scheduling, system control, minor preventive maintenance, cryptographic changes, warranty tracking, usage documentation, and system configuration control is often necessary to ensure that the VTC system is utilized effectively. [Ref. 5:pp. 25-26]

Development of downstream maintenance requirements is necessary to ensure that system downtime, due to preventive and corrective maintenance, is handled in an efficient and timely fashion. Also, the identification and procurement of material support items that are needed to meet the operational and maintenance requirements is extremely important. Material support channels must be established with suppliers to ensure that system downtime due to lack of resources is minimized. [Ref. 5:p. 26]

Program evaluation is necessary to ensure that the VTC system continues to benefit the communications requirements of the organization's VTC users. To achieve this goal, periodic review of the VTC system's performance and VTC users' suggestions (feedback) will be helpful. [Ref. 5:p. 26]

D. FURTHER SUGGESTIONS

There are many other related topics that should be considered for future research. For the sake of brevity, the author will simply list these topics. These topics are:

1. Requirements Document for NPS VTC Facility.
2. Determination of Specific Applications for Video Classroom at NPS.
3. Applications of workstation VTC at NPS.
4. The Current Status of BITS in the U.S. Navy (Is it progressing as originally planned? What impact does a possible delay have on the implementation of FTS2000?).
5. What is the best method for NPS to Implement FTS2000 Switched Digital Integrated Services, which is the FTS2000 proposal for integrating voice, data, imaging, and voice through a single FTS2000 network connection?

In addition, if more information is needed on the subjects of VTC and VTC implementation, there are numerous individuals and organizations that would be able to provide assistance. Excellent sources are:

1. Tom Zeitvogel
   Telemanagement Resources International, Inc.
   1138 Caballo Court
   San Jose, CA 95132
   (408)-926-9110

2. Ed Somerville
   Sales Director, Federal Government
   Compression Labs Incorporated
   1760 Business Center Drive
   Suite 150
   Reston, VA 22090
   (703)-438-8256

3. Tim Young
   General Services Administration
   Information Resources Management Service
   13221 Woodland Park Dr. 3rd Floor
   Herndon, VA 22071
   (703)-904-2928

4. International Teleconferencing Association (ITCA)
   1150 Connecticut Ave. NW
   Suite 1050
   Washington, D.C. 20036
   (202)-833-2549

5. Joan Rucker
   VTC Manager
   NSWSES
   Port Hueneme, CA 93043
   (213)-982-8195

APPENDIX A. VIDEO TRANSMISSION PRIMER

The process of sampling, transmitting, and reproducing a full-motion, color, TV image is quite complex because video signal transmission must incorporate some means of relaying information concerning these four factors:

1. A perception of the distribution of luminance or simply the distribution of light and shade.
2. A perception of depth or a three-dimensioned perspective.
3. A perception of motion relating to the first two factors.
4. A perception of color (hues and tints).[Ref. 59]

Video transmission systems must be capable of interpreting the luminance of a moving image in terms of height, width, depth, and time. As shown in Figure 6, video transmission systems translate the luminance of a moving image by employing a video scanner to view each individual frame of that moving image. [Ref. 59:pp. 515-516]

For each frame, a horizontal strip of discrete square elements (pixels) is scanned from left to right. Once the end of the first horizontal strip is reached, a lower horizontal strip is scanned, and so on, until the entire frame has been scanned. As the scanning of each individual pixel occurs, its luminance value is translated into a current or voltage level which is transmitted over the system. [Ref. 59:p. 516]

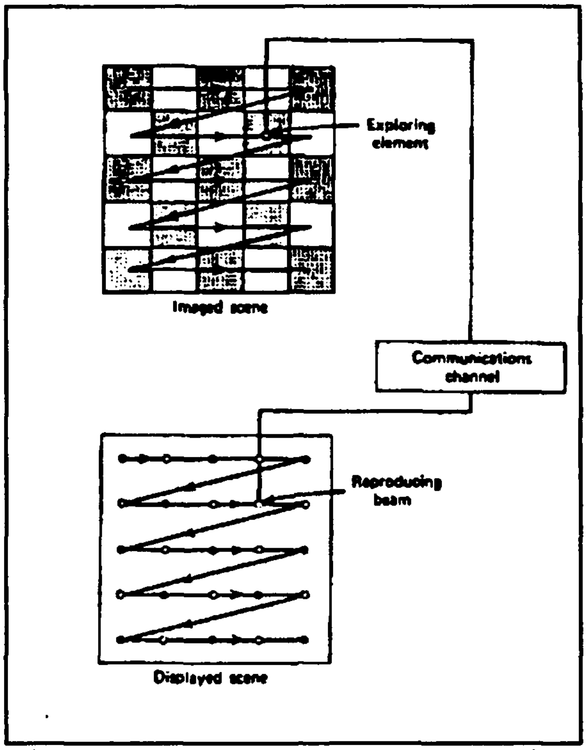

Figure 6 Video Image Scanning [Ref. 59:p. 516]

The National Television Systems Committee (NTSC) standard for television image resolution (in the United States) is 525 horizontal scanning lines. It is the number of scanning lines that determines the resolution of a picture. [Ref. 59:p. 516]

The aspect ratio (width-to-height ratio) of a video image that is almost used universally is 4:3. Therefore, a video image that has a vertical height of 525 lines will have a horizontal width of 700 lines[25]. In reality, the maximum

[25] 525 horizontal scanning lines that are stacked on top of each other produces a vertical height of 525 lines. 700 vertical scanning lines that a placed from left to right gives a horizontal width of 700 lines.

active lines is 491 vertical pixels and 652 horizontal pixels. [Ref.59:pp. 516-517]

Since the actual amount of vertical detail that can possibly be reproduced is 64-87 percent of the active scanning lines, a video transmission system must be capable of transmitting the translated luminance of approximately 224,264 (491 vertical pixels x 525 horizontal pixels x .87) pixels for each individual frame of a moving image. This whole process must occur in a matter of microseconds (μsec). [Ref. 59:p. 516]

APPENDIX B. T1 NETWORKING

In the early 1960s, AT&T developed and implemented digital voice systems known as T1 carriers. Originally, T1 meant a transmission facility that consisted of twisted-pair wires (one for each direction) and repeaters at intervals of about one mile. [Ref. 60]

Today, T1 and the expanded system of T carriers refer to a general system of facilities (see Table IV), a Digital Signal Designation (DS), and various framing conventions. The DS is nothing more than a bit rate for a particular T carrier. The voice-digitization rate (VDR) scheme that serves as the backbone for the entire series of Digital Signal Designations is 64 kbps or DS0. [Ref. 60:pp. 723-724] Today, T1 refers to any digital transmission facility capable of transmitting 24 voice grade channels (equivalent of 24 DS0) at the rate of 1.544 Mbps (DS1). Today's T1 facilities are known for their ability to support any arbitrary mix of voice channels and data channels. [Ref. 60:p. 723]

A primary advantage of digital T1 facilities is the wider variety of transmission media that are available to handle digital T1 facilities. The most notable transmission media for digital T1 are:

1. Twisted-pair wires that were a part of original T1 facilities.

2. Microwave relay facilities that require a line of sight transmission path and a Federal Communications Commission (FCC) license.

3. Infra red relay facilities that also require a line of sight path but do not require a FCC license.

4. Optical fiber that only requires repeaters every 100 miles and is virtually immune to noise effects.

5. Coax cable that requires repeaters every 40 miles. [Ref. 60:pp. 117-139, 724]

Obviously, the primary advantage of T1 facilities is their channel capacity, which allows various communications media (voice and data) to share a common link or "pipeline." However, the trend is for the system of T carriers to continue to evolve and grow into FT3, T4M, and so on, to accommodate requirements for even more bandwidth.

Table IV AT&T Digital Facilities

System Name	Medium	Voice Grade Channels	Bit Rate (Mbps)	Repeater Spacing (Miles)
T1	Wire Cable	24	1.544	1
T1C	Wire cable	48	3.152	1
T2	Wire Cable	96	6.312	1-25
FT3	Optic Fiber	672	44.736	4
FT3C	Optic Fiber	1344	90.524	4
FT4E-144	Optic Fiber	2016	140.000	8-12
T4M	Coaxial	4032	274.176	1.1
FT4E-432	Optic Fiber	6048	432.000	8-12

[Ref. 60:p. 724]

APPENDIX C. INTEGRATED SERVICES DIGITAL NETWORK (ISDN) PRIMER

Presently, telephone users have the luxury of knowing that they can make a voice call to practically anywhere in the world. Virtually every residential and business subscriber loop that is connected to a local exchange carrier (LEC) utilizes analog transmission schemes. Analog transmission is acceptable for voice communications. However, it is undesirable for data communications, because analog transmission is inefficient and prone to errors for data communications.

The advent of digital technology has made it possible and economical to transmit numerous forms of information, but not on the same world-wide basis as voice communications. Eventually, the Integrated Service Digital Network (ISDN) will provide residential and business users with a world-wide digital transmission service for voice, data, text, graphics, music, and video that is economical and flexible. ISDN will provide end-to-end digital connectivity from a standard interface plug. [Ref. 60:p. 743]

ISDN evolved from the telephony Integrated Digital Network (IDN) and was intended as an evolution of the existing telephone network, with the IDN providing the necessary digital switches and digital transmission on interoffice trunks. ISDN focuses on three central ideas:

1. Standardization of services offered to subscribers in order to foster international compatibility.

2. Standardization of the user-network interfaces in order to foster independent terminal equipment and network equipment development.

3. Standardization of network capabilities in order to foster user-network and network-to-network communications. [Ref. 60:p. 743]

A. ISDN CHANNELS

There are three types of ISDN channels. These channels are named the B-channel, D-channel, and H-channel. Each channel type has its own special features. Additionally, there are plans for an E-channel, but no decisions have been made regarding its use.

First of all, the ISDN B-channel has a data rate of 64 Kbps and is utilized for user information. The B-channel can be circuit-switched, packet-switched, or semipermanent connected.

Next, the ISDN D-channel has a data rate of 16 or 64 Kbps, depending on which user-network interface is used. This is the basic rate or primary rate (to be explained shortly), and is utilized for control information and low-speed user information. Because the D-channel is used to transmit control information that is crucial for the operation of the network, the D-channel data is packet-switched and is **always** open for control purposes.

Finally, the ISDN H-channel has a variety of channels that are defined, but none of them have been supported by service vendors so far. The H0-channel has a data rate of 384 kbps, the H11-channel has a data rate of 1536 kbps, and the H12-channel has a data rate of 1920 kbps. All H-channels are derived from multiples of the B-channel. Regardless of the data rate, the ISDN H-channel will be utilized for high-speed user information. The H-channel can be circuit-switched, packet-switched, or be semipermanently connected. [Ref. 61]

B. ISDN TRANSMISSION STRUCTURE FOR ISDN CHANNELS

ISDN channels are defined at the user-network interface and from one ISDN exchange to the next. This is to ensure interoperability and interconnectivity on the network.

At the user-network interface, the transmission structure specifies the number of B and D channels that are available for a particular data rate. This is done so that customer premise equipment (CPE) and network equipment manufacturers can deliver standardized equipment to their customers.

Between ISDN exchanges, the transmission structure is concerned with which particular networks are responsible for handling the various ISDN channels. This effort is aimed at standardizing network capabilities so that network-to-network communications may be fostered.

1. User-Network Interface

The user-network interface is defined as the juncture where privately owned CPE is connected to the ISDN. The user-network interface will be explained in more detail in just a moment.

In the United States, at the user-network interface, ISDN channels are offered in Basic Rate Interface (BRI) and Primary Rate Interface (PRI) packages. The BRI is comprised of two B-channels and one 16 Kbps D-channel with an overall data rate of 144 Kbps. But after the ISDN supplements this rate with framing control and other overhead bits, the total bit rate equals 192 kbps. The PRI is comprised of 23 B-channels and one 64 Kbps D-channel with an overall data rate of 1.544 Mbps. [Ref. 61:pp. 244-246]

2. From One ISDN Exchange to the Next

Between ISDN exchanges, circuit-switched networks, packet-switched networks, dedicated networks, and Common Channel Signaling System Number 7 (CCSS7 - a common channel signaling protocol used for high-speed networks) networks support ISDN channels in the following manner:

1. Circuit-switched networks carry B and H-channels.
2. Packet-switched networks carry B, H, and D-channels.
3. Dedicated networks carry B and H-channels.
4. CCSS7 carries D-channels.

Please note that D-channels carrying control signals are packet-switched through CCSS7 networks and D-channels carrying slow-speed information are relayed through packet-switched networks. [Ref. 61:p. 244-246]

C. ISDN User-Network Interface

The analysis of the ISDN user-network interface would not be clear without first defining the meaning of the terms functional groupings and reference points. Figure 7 is a diagram of the ISDN user-network interface.

The functional groupings of the ISDN user-network interface are the specific capability requirements that are needed within a specific group. These functions are performed by an assortment of hardware and software. The reference points are the dividing lines between functional groupings. Quite often, the reference points correspond with a physical interface between pieces of hardware. [Ref. 60:p. 743]

1. Functional Groupings

The functional groupings of the ISDN user-network interface are differentiated as follows:

1. NT1 is the physical and electrical termination of the subscriber loop. It connects the 4-wire subscriber wiring to the 2-wire local loop. Up to eight terminal devices can be addressed by NT1.

2. NT2 is an ISDN private branch exchange (PBX) that may be combined with NT1. Its primary function is to multiplex 23 B-channels and one D-channel onto the line to form the PRI (1,544 Mbps). NT2 is unnecessary for BRI.

3. TE1 is an ISDN compatible terminal.

4. TE2 is a non-ISDN compatible terminal.

5. TA is an adapter for non-ISDN compatible terminals that is responsible for rate adaption and signaling conversion. TA may be combined with NT2. [Ref. 60:pp. 743-746]

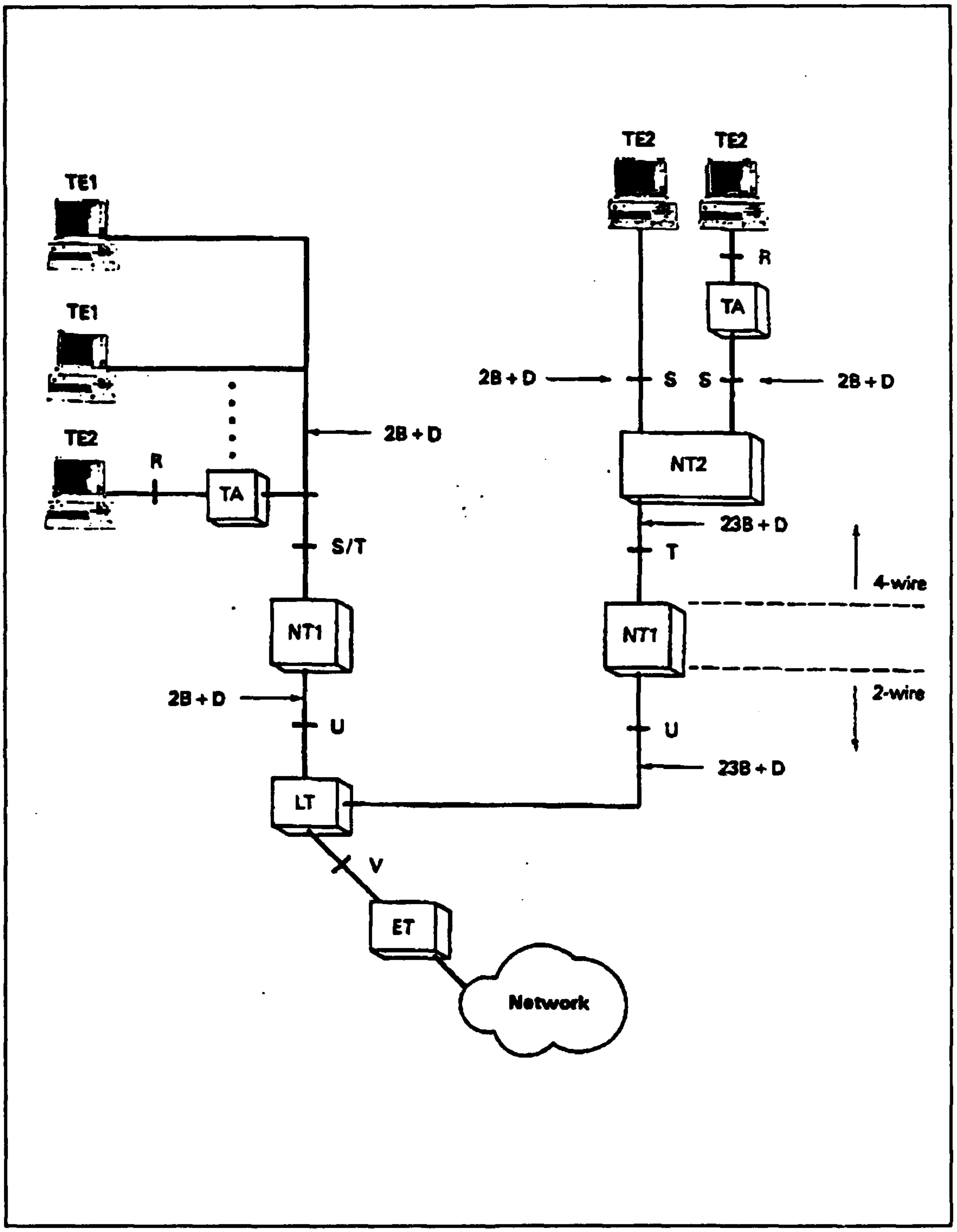

Figure 7 ISDN User-Network Interface[Ref. 60:p. 745]

2. Reference Points

As previously stated, the reference points serve as the logical (and sometimes physical) interface between the functional groupings. Reference point U is defined as a two-wire (full-duplex) connection between the line termination (LT) equipment of the ISDN central office and NT1 (BRI and PRI). Reference point T is defined as a four-wire (one pair for each direction) connection on the customer side of NT1. It connects NT1 and NT2 (BRI and PRI). Reference point S is a four-wire (one pair in each direction) connection between NT2 and TE1 (or TA). There will be a combined S/T reference point if NT2 is nonexistent. Reference point R is an interface between TA and TE2 and reference point V is the interface that separates the LT and the exchange termination (ET) equipment of the ISDN central office. [Ref. 60:p. 746]

APPENDIX D. OPEN SYSTEMS INTERCONNECTION (OSI) PRIMER

The subject of the Open Systems Interconnection (OSI) model is frequently mentioned when discussing interoperability requirements among data networks. In the past, the telecommunications industry has nurtured a vendor specific mentality that resulted in varied telecommunications products with non-compatible interfaces for their customers. In effect, the vendor specific mentality served to impede communications between systems.

Since most communications systems provide many functions for their users, more than one convention for communication among the various functions (or layers) of the communications system are needed. These communications methods (referred to as protocols) define how the various functional **layers** communicate with one another. These layered protocols meet the following criteria:

1. Provide a logical decomposition of a complex system into smaller, more understandable parts (layers).

2. Provide for standard interfaces between systems; for example, provide standard interfaces between the software or hardware modules that comprise the layers.

3. Provide for symmetry in functions performed at each site in the network. Each layer performs the same functions as its counterpart in other machines in the network. This approach greatly simplifies the interfaces between the layers of the network.

4. Provide a means to predict and control the consequences of any changes made to the network system's logic (software or microde); the logical decomposition aids in making these changes.

5. Provide a standard language to clarify communications between and among network designers, managers, vendors, and users when discussing the logic of network systems. [Ref. 60:p. 15]

The OSI model was created by the International Organization for Standardization (ISO)[26] and other standards organizations in response to the vendor specific mentality. The main purpose of the OSI model is to perform the following functions:

1. Establish a common basis for standards development.

2. Qualify products as "open" by their use of these standards.

3. Provide a common reference for standards...

4. Provide standards for communications between systems.

5. Remove any technical impediment to communication between systems.

6. Eliminate the need to describe the internal operation of a single system.

7. Define the point of interconnection for the exchange of information between systems.

8. Narrow the options in order to increase the ability to communicate between systems without expensive conversions and translations. This means different vendors' products can communicate with each other more easily. [Ref. 60:pp. 15-16]

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[26] The ISO is a voluntary organization that consist of representatives from the national standardization organizations of each member country. ISO activities are centered around standardization issues that pertain to users and manufactures.

There are seven defined layers within the OSI model that allow the OSI model to accomplish its specified functions (listed above). These seven layers are:

1. Physical Layer - activates, maintains, and deactivates the physical circuit between the terminal equipment (user interface) and the circuit-terminating equipment (interface to the communications link.

2. Data Link Layer - transfers data across the communications link.

3. Network Layer - specifies the user interface into a network, as well as the interface of the terminal equipment with other terminal equipment on the network.

4. Transport Layer - provides the interface between the data communications network and the upper three layers of the OSI model. It is designed to keep the user isolated from some of the physical and functional aspects of the network.

5. Session Layer - serves as the user interface to the transport layer. It provides an organized means of exchanging data between users, such as simultaneous transmission, alternate transmission, checkpoint procedures, and resynchronization.

6. Presentation Layer - accepts data (integer or character) from the top layer of the OSI model and negotiates with its peer level (same level on the other terminal equipment) as to the syntax of the data (ASCII, teletype, etc.).

7. Application Layer - handles the semantics of data. It contains service elements (programming languages, E-mail, etc.) that support the needs of the end user. [Ref. 60:pp. 16-18]

APPENDIX E. NAVY BASE INFORMATION TRANSFER SYSTEM (BITS) PRIMER

In 1986, the U.S. Navy started an information systems modernization initiative to exploit the evolving communications standards, to respond to the newer communications technologies, and to overcome the deficiencies of existing information transfer systems. The Office of the Chief of Naval Operations (CNO) defined the Navy Data Communications Control Architecture (NDCCA)[27], which divides naval communications into three sub-architectures: the afloat, the long-haul, and the Base Information Transfer System (BITS). [Ref. 23:p. 1-1]

More recently, the NDCCA was replaced by the Navy Communications Control Architecture (NCCA). This change was enacted to reflect the merger of communications and data within the Navy. However, the NCCA was also abandoned when the Naval Computers and Telecommunications Command (NCTC) decided to consolidate the NCCA's afloat and long-haul sub-architectures with existing command and control (C^2) architectures of the U.S. Navy and Marine Corps. This new architecture is known as COPERNICUS[28].

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[27] The NDCCA is no longer a specified architecture for naval communications.

[28] COPERNICUS is the DOD's new C^2 architecture.

The COPERNICUS architecture has been designed to facilitate the exchange of shore-based sensor data [from a streamlined Global Information Exchange System (GLOBIXS)] with organic sensor data afloat [via the Tactical Data Exchange Systems (TADIXS)]. When COPERNICUS is fully implemented, it will shift the focus of Command, Control, Communications, and Intelligence (C^3I) away from the Naval Communications Area Master Stations (NAVCAMS). Instead, C^3I will focus on the shore-based users in the Fleet Command Centers (FCC) and the afloat users in the Tactical Flag Command Centers (TFCC). [Ref. 62]

The BITS sub-architecture[29] is a "sub-set" of the COPERNICUS architecture. As such, BITS will provide interbase connectivity and capacity in support of the COPERNICUS architecture. [Ref. 63]

Figure 8 demonstrates that the BITS architecture is based on the following set of architectural concepts:

1. Integration of voice, data, and video by migration toward the target architecture based on ISDN standards.

2. Unified systems management through the use of a Network Management Center (NMC) to provide efficient and responsive service to users in a cost-effective manner.

3. Interoperability through the use of OSI protocols.

4. Interconnectivity to all users including interbase, intrabase and ships at the pier.

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[29] The BITS sub-architecture is still a valid architecture definition. BITS is supported by hardware and software that complies with Navy Base Communications Specifications.

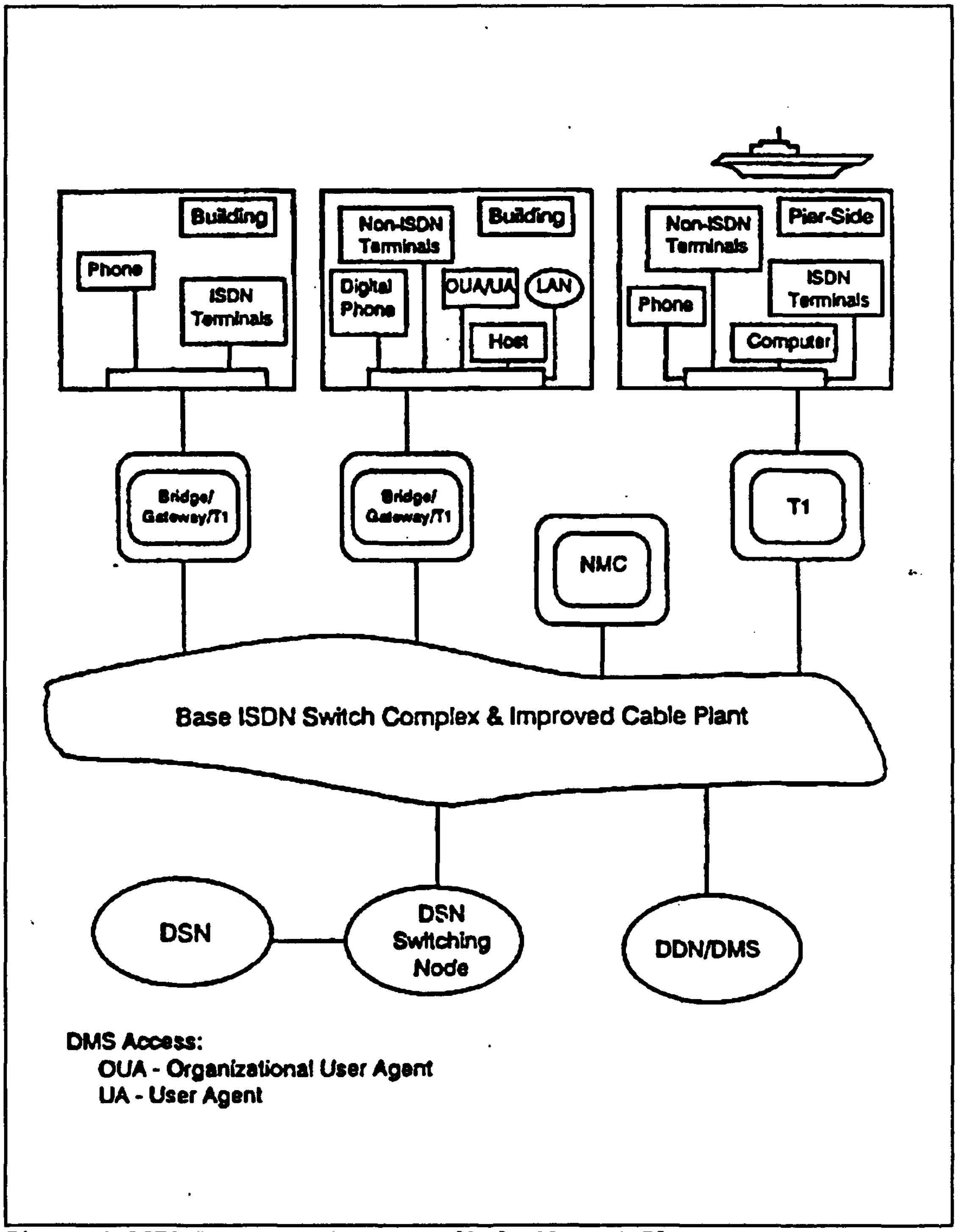

Figure 8 BITS Target Architecture[Ref. 23:p. 4-7]

5. Security by evolution to a multi-level secure (MLS) architecture. [Ref. 23:p. xiii]

Migration to the BITS architecture will occur in three phases: current phase, interim phase, and target phase. The availability of OSI and ISDN products plus the time that is needed for prototyping, planning and development are key factors in the transition to BITS. [Ref. 23:pp. xv-xvi]

The "current phase" extends until 1992. No significant changes to the existing base communications are expected, but bases are expected to submit their plans for the transition to the BITS architecture through the Base Communications Plan (BCP). [Ref. 23:p. xv]

The "interim phase" will extend from 1992 through 1996. Prototypes will be installed and tested, and the interim BITS architecture will be implemented at many Navy bases. [Ref. 23:p. xv]

The final phase, or "target phase," will extend from 1996 and beyond. BITS will migrate to ISDN standards and OSI protocols, and the NMC will become fully automated. [Ref. 23:p. xvi]

It should be noted that the implementation of the BITS architecture is progressing slowly. It is estimated that the time frames associated with each of the three phases will be extended by two additional years. [Ref. 64]

APPENDIX F. FEDERAL TELECOMMUNICATIONS SERVICE (FTS)2000 PRIMER

The General Services Administration (GSA) manages two contracts that will provide a modern, low-cost telecommunications network and services for all Federal government agencies. Federal law 101-136 mandates use of the network by all Federal agencies within the continental U.S., Puerto Rico, Guam, and the Virgin Islands, except as exempted by the Warner Amendment [Ref. 65].

This law requires the Federal agencies to use FTS2000 for their telecommunications services, unless a particular service is not offered as part of the FTS2000 contract. In this case, justification must be made to the Congress (specifying the requirement for this service). Once Congress has granted permission, the Federal agency may then submit a Request for Proposals (RFP) to other vendors to provide this specific service (that is not offered by FTS2000). [Ref. 65]

The prime contractors for the Federal government are AT&T with 60 percent of the system (for the "A" Network users) and U.S. Sprint with 40 percent of the system (for the "B" Network users). By dividing the contract among the two competitors in long distance phone services, the GSA believes that FTS2000 will inherit the mutually exclusive advantages that both companies can offer.

FTS2000 is expected to greatly enhance the telecommunications capabilities of the Federal government agencies and especially the military. FTS2000 will offer the following services:

1. Switched voice service including long distance voice, audio conferencing, 800 services, and recorded message announcements.

2. Switched data service offering dial up data calls at 56/64 kbps.

3. Dedicated transmission service with point-to-point data transmission at 9.6/56/64 kbps plus T1.

4. Packet switch service with dial up or dedicated access to X.25 networks, E-mail service, and bulletin board service.

5. Video Transmission Service (VTS) offering both wideband and compressed, full-motion video.

6. Switched digital integrated service providing T1 for volume discounts and ISDN access at the primary rate or basic rate. [Ref. 24:pp. 3-9]

Currently, FTS2000 network A is <u>not</u> interoperable with network B. This has been a source of numerous complaints by FTS2000 users. However, the GSA Fine Point Committee[30] has responded to these complaints by submitting a statement of work to AT&T and U.S. Sprint requesting a resolution to the interoperability problem for FTS2000 services. No projections have been made as to when the interoperability between FTS2000 network A and network B will occur, but the GSA has made the resolution of this problem a <u>high</u> priority. [Ref. 65]

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[30] The GSA's Fine Point Committee has been tasked to troubleshoot and resolve the various FTS2000 user related problems.

APPENDIX G. VTC USER'S ANALYSIS QUESTIONNAIRE

VIDEO TELECONFERENCING (VTC) USER'S ANALYSIS QUESTIONNAIRE

FOR

THE NAVAL POSTGRADUATE SCHOOL

I. Discussion

I am seeking your assistance by requesting that you please respond to this survey that was designed for my thesis - *Video Teleconferencing User Requirements and Feasibility at the Naval Postgraduate School*. **Please read the purpose behind the line of questioning in each section before you attempt to answer any of the questions.** This is extremely important, because the purpose listed for each section will assist you in reducing the scope of your considerations.

Also, I want you to understand that the overall objective of this survey is to determine if the needs and problems of the potential video teleconferencing (VTC) users at the Naval Postgraduate School (namely you) can be resolved by VTC. I also wish to include you in the VTC implementation process from the very beginning because your participation is crucial for the development of a VTC system that will primarily be used by you.

II. Work Requirements

A. Purpose

The purpose of section one is to determine if there are any job related problems that could possibly be resolved by the implementation and use of video teleconferencing (VTC).

B. Questions

1. What are the top three difficulties that you have in completing your job? **(Please prioritize your responses.)**

    a.

    b.

    c.

2. What are the three most time consuming aspects of your job? **(Please prioritize your responses.)**

    a.

b.

c.

III. Business Meetings

A. Purpose

The purpose of section two is to determine if there are any problems that occur with meetings that could possibly be resolved by the implementation and use of video teleconferencing (VTC).

This is **EXTREMELY IMPORTANT.** Please limit your answers to considerations on the following types of meetings:

1. Those meetings that are attended by NPS personnel but occur at dispersed locations (away from NPS) and typically last anywhere from a few minutes up to three hours.

2. Those meetings that are attended by people from dispersed locations (other than NPS) but occur at NPS and typically last anywhere from a few minutes up to three hours.

B. Questions

1. Are the majority of your meetings regularly scheduled or do they occur as needed?

2. How many people usually participate?

3. Do the meetings require support material? If so, is the support material prepared before the meeting, or is it created as the meeting progresses?

4. What kind of support material (graphs, slides, viewgraphs, etc.) is used? **(Please be as specific as possible.)**

5. Were there any meetings that should have taken place but did not? What was the reason? What effect did it have on your ability to perform your job?

IV. Travel

A. Purpose

The purpose of section three is to determine if there are any problems or excessive costs due to the impact of travel to meetings. The results of this section will assist the researcher in determining if VTC is an acceptable alternative to travel.

B. Questions

1. What cities do you normally travel to? What organizations do you normally visit? **(Attempting to determine if these locations have access to VTC.)**

2. How long does the travel normally take, and how long do you normally stay at the destination? **(Attempting to determine if travel time is excessive when compared to the actual time of the meetings.)**

3. When you travel to certain destinations, who normally travels to that same destination?

4. Is anyone needed who cannot attend because of budget and/or time constraints? **(Please elaborate.)**

5. Who comes to see you?

V. Education

A. Purpose

The purpose of this section is to determine if there are any applications in education that can be directly enhanced by the use of VTC.

B. Questions

1. What courses within your curriculum have applications that are directly translatable to video? (Please disregard those courses that require "hands-on" experiences to enhance learning.)

2. What curriculum activities have applications that are directly translatable to video? **(Attempting to determine if activities such as thesis research and professional seminars can be enhanced by VTC.)**

APPENDIX H. VTC ROUND TABLE DISCUSSION AGENDA

VIDEO TELECONFERENCING (VTC) FEASIBILITY: ROUND TABLE DISCUSSION AGENDA

PARTICIPANTS:	CAPT Sarepera (Code 03) Dean Frew (Code 05) Dr. Marto (Code 08) Dr. Bruneau (Code NS) Dr. Panholzer (Code SP) CDR Tulloch Dr. Suh MAJ Schwendtner
FACILITATOR:	LT Martin E. Jolly
DATE:	Tuesday, May 14, 1991
TIME:	1000 hours
PLACE:	Herrmann Hall, Superintendent's Conference Room
SUBJECT:	VTC Feasibility at the Naval Postgraduate School (NPS)

1-2 min. Open the discussion

Introduce ourselves

State the purpose of the discussion

15 min. 1. What is the nature of the problems (below) that have prompted NPS to consider VTC as a possible solution for those problems?

Problem 1 - NPS is missing opportunities to conduct more business abroad due to fiscal and manpower constraints.

Problem 2 - NPS can no longer afford to rely exclusively on travel as the means for conducting business meetings and face-to-face information exchange.

- PIECES Framework

A. Performance Analysis:

- What opportunities are NPS missing?
- Personnel away from their jobs too much?
- Work accumulation during absences?
- Not enough time to attend all of the meetings?
- Beneficial if more people could attend important meetings?
- Thin staffing requires careful selection of who attends the meetings and who does not?

B. Information Analysis:

- Lack of timely information?
- Need for information redundancy?
- Too much information resulting from information redundancy?
- Inaccurate information?

C. Economic Analysis

- Travel budget - how much?
- Travel budget sufficiency?
- Travel budget deficits?
- Travel budget reductions?

D. Control and Security Analysis

- How does NPS ensure that travelling to meetings is not excessive?
- How does NPS ensure that privacy and security issues are not abused when travelling to meetings?

F. Efficiency Analysis

- How does travelling to meetings allow NPS to get more from its resources (people, money, and other resources) than other forms of communications?

G. Service Analysis

- Does travelling to meetings provide better service for NPS staff, faculty, and students?

15 min.

2. What is the nature of the opportunities that VTC provides for NPS?

- **PIECES Framework**

A. Performance Analysis:

- Personnel at their jobs more often?
- Work accumulation reduced?

- More time for meetings?

- More people attend the meetings?

- Thinly staffed does not matter as much?

- Enhanced productivity?

B. Information Analysis:

- Solution to the lack of timely information?

- Reduction of the need for information redundancy?

- Reduction in the amount of information to be disseminated?

- Reduction in the amount of inaccurate information?

- Access to more information?

- Access to new types of information exchange (i.e., video classroom and others)?

C. Economic Analysis

- VTC budget - how much?

- VTC costs

  - - What are your perceptions?

  - - What cost for a VTC system would be considered excessive?

  - - Is a cost-benefit analysis really necessary or is a statement of VTC costs sufficient?

D. Control and Security Analysis

- What types of controls are needed?

- What are the relevant privacy and security issues for the new system?

F. Efficiency Analysis

- How does the new system allow NPS to get more from its resources (people, money, and other resources) than the status quo?

G. Service Analysis

- Will the new system provide better service to the NPS staff, faculty, and students who need to conduct meetings?

- Will the new system provide new educational services that have not been possible in the past?

5 min. 3. What are the end-user's goals for and expectations of the VTC project?

10 min. 4. What is the scope of the VTC system?

- To what key events, inputs or data must the VTC system respond?

- What responses or outputs must the VTC system produce?

- To what other systems (or networks) must VTC system connect?

5 min. 5. What personnel are directly or indirectly involved with the VTC system? Who will be the principal point of contact(s) (POCs) for the end users?

5 min. 6. What are the anticipated benefits of the VTC opportunity?

5 min. 7. Are there any constraints on the procurement of a VTC system - such as deadlines, policies, contracts, budget, or the like - that can't be changed?

5 min. 8. What ideas exist for exploiting the VTC opportunity?

65 minutes
\+ 25 minutes *for follow-up questions and redirection*

90 minutes allotted for the discussion (1000 - 1130)

LIST OF REFERENCES

1. Whitten, Jeffrey L. and others, *Systems Design & Analysis Methods*, p. 767, Richard D. Irwin, Inc., 1989.

2. Department of Defense
UNCLASSIFIED Draft Directive to all Department of Defense Activities, Subject: Teleconferencing Activities, Systems and Networks, 03 July 1990.

3. Inglis, Andrew F., *Electronic Communications Handbook*, p. 18.6, McGraw-Hill, Inc., 1988.

4. Langley, Grahm, *Telephony's Dictionary*, p. 16, Telephony Publishing Corp., 1982.

5. Keiper, R., *The VTC Implementer's Guide*, pp. 4-5, Keiper Associates, Inc., 1988.

6. Ang, Peng H. and others, "Video Compression Makes Big Gains," *IEEE Spectrum*, p. 16, October 1991.

7. Dickerson, Francis, *Compression Labs, Incorporated 1990 Annual Report*, p. i, Paige Johnson Design, Inc., 1990.

8. Fuller, Carol, "News Bits," *Teleview, 2nd Quarter 1990*, p. 2, Compression Labs, Inc., 1990.

9. Schwartz, Jeffrey, "Talking Heads," *Communications Week*, p. 37, January 21, 1991.

10. Telephone conversation between Robert Keiper, KAI, and LT Martin E. Jolly, 5 February 1991.

11. Fuller, Carol, "A Quick Look at Videoconferencing with FTS2000," *Teleview, 3rd Quarter 1990*, p. 2, Compression Labs, Inc., 1990.

12. Sullivan, Robert, *Compression Labs, Incorporated*, p. 1, Paine Webber, Inc., 1990.

13. Compression Labs, Incorporated, "CLI's New Rembrandt II/06 Codec Offers 2:1 Improvement in Picture Quality at Low Bandwidths," *CLI News Release*, p. 1, CLI, January 15, 1990.

14. Compression Labs, Incorporated, *Rembrandt II/06 Video Codec*, p. 1, CLI, 1989.

15. Compression Labs, Incorporated, "Compression Labs Announces Next Generation Videoconferencing Architecture", *CLI News Release*, p. 1, Compression Labs, Inc., January 15, 1990.

16. Schwartz, Jeffrey, "Video Gear Preview," *Communications Week*, p. 10, April 29, 1991.

17. Crockett, Barton, "CLI Announces Revised Version of Rembrandt," *Network World*, p. 6, June 24, 1991.

18. Fuller, Carol, "CLI Introduces the Rembrandt II/VP," *Teleview, 3rd Quarter 1991*, p. 1, Compression Labs, Inc., 1991.

19. Datapro Management of Telecommunications, Vol. 1, Report MT20-420-101, *Integrated Services Digital Networks (ISDN): An Overview*, p. 1, McGraw-Hill, Inc., April 1991.

20. Freiberger, Paul, "Overcoming Obstacles," *San Francisco Chronicle*, April 28, 1991.

21. Schwartz, Jeffrey, "Videoconferencing is Still Too Pricey," *Communications Week*, p. 26, April 22, 1991.

22. Vietor, Richard H., "Conclusion: The Process of Regulatory Change," *Telecommunications in Transition*, p. 195, Harvard Business School, 1986.

23. The Navy Data Automation Command, *Navy Base Information Transfer System (BITS) Sub-Architecture*, p. xii, The MITRE Corporation, Washington, D.C., 24 March 1989.

24. Datapro Management of Telecommunications, Vol. 1, Report MT10-420-101, *FTS2000 Network*, p. 1, McGraw-Hill, Inc., April 1991.

25. Messmer, Ellen, "GSA Shuffles Navy Back to AT&T Under FTS2000," *Network World*, p. 4, August 12, 1991.

26. Messmer, Ellen, "GSA Forces FAA, NASA and Other Agencies to FTS2000," *Network World*, p. 4, June 17, 1991.

27. Taff, Anita, "Government Officials: FTS2000 Too Costly, Service Poor," *Network World*, p. 4, October 28 1991.

28. Taff, Anita, "GAO Finds FTS2000 Services Overpriced," *Network World*, p. 13, September 23, 1991.

29. Messmer, Ellen, "GSA Chief Targets FTS2000 Billing," *Network World*, p. 15, October 7, 1991.

30. "GSA Unveils FTS2000 Renegotiation Plans," *Network World*, p. 15, October 14 1991.

31. Messmer, Ellen, "Government Groups Denounce Bill to Alter Government Procurement," *Network World*, p. 10, November 11, 1991.

32. "Senate Postpones FTS2000 Hearing," *Network World*, p. 2, September 9, 1991.

33. Briere, Daniel, "Switched Data Offers More for Larger Users," *Network World*, p. 1, June 11, 1990.

34. Dickerson, Francis, *Compression Labs, Incorporated, 1989 Annual Report*, p. 17, Paige Johnson Design, Inc., 1989.

35. Borden J., "Introduction and Overview of Teleconferencing," *The Teleconference Resource Book: A Guide to Applications and Planning*, p. 83, Elsevier Science Pub. Co., 1984.

36. Rash, P.R., "Video-teleconferencing," *The Teleconferencing Resource Book: A Guide to Applications and Planning*, p. 49, Elsevier Science Pub. Co., 1984.

37. Knutson, Lawrence L., "Deregulation's Unfriendly Skies," *San Francisco Examiner*, p. D-12, March 31, 1991.

38. Carroll, Doug, "Airfares for Business Fliers are Taking Off," *USA Today*, p. 1C, October 24, 1991.

39. Telemanagement Resources International, Inc., *Needs Assessment*, p. 3, TRI.

40. Mitchell, James J., "Next Best Thing to Being There," *San Jose Mercury*, p. 1E, February 22, 1991.

41. Naval Sea Systems Command, AEGIS Program Office, *Naval Sea Systems Command Video Teleconferencing Network*, p. 9, Keiper Associates, Inc. 1988.

42. Zeitvogel, Tom, "Teleconferencing: An Overview," prepared and presented by TRI for Nevada Bell at Reno, NV, March 1991.

43. Miller, John, "New Technologies Aid Videoconferencing," *Government Data Systems*, p. 28, November/December 1986.

44. Compression Labs, Incorporated, "CLI Third Quarter Highlights," *CLI News Release*, p. 1, Compression Labs, Inc., 1990.

45. Earon, Anne, *Videoconferencing and Business TV*, TRI, January 1991.

46. Fuller, Carol, "FTS2000 Network Videoconferencing Service Attracting Major Users," *Teleview, 1st/2nd Quarter 1991*, pp. 1-5, Compression Labs, Inc., 1991.

47. Telephone conversation between Wanza Barnes, GSA and LT Martin E. Jolly, 04 December 1991.

48. Telephone conversation between Tim Young, GSA, and LT Martin E. Jolly, 10 May 1991.

49. Interview between Ms. Debbie Walsh, Fort Ord VTC Manager, and LT. Martin E. Jolly, 26 April 1991.

50. Telemanagement Resources International, Inc., *Teleconferencing Project Management*, pp. 5-6, TRI.

51. Telemanagement Resources International, Inc., *System Design*, pp. 1-4, TRI.

52. Telemanagement Resources International, Inc., *Promotions and Training Support For Videoconferencing*, p. 1, TRI.

53. Salamone, Salvatore, "Fine-tuning the Videoconference," *Network World*, p. 38, July 1, 1991.

54. Telemanagement Resources International, Inc., *Videoconferencing Market Projections*, p. 21, TRI, January 1991.

55. Government Services Administration UNCLASSIFIED Facsimile Memorandum to LT Martin E. Jolly Subject: AT&T's FTS2000 Pricing, p. 4, 10 October 1991.

56. Telephone conversation between Debbie Walsh, Fort Ord VTC Manager, and LT Martin E. Jolly, 29 May 1991.

57. Government Services Administration UNCLASSIFIED Facsimile Memorandum to LT Martin E. Jolly Subject: FTS2000 Videoconferencing, pp.3-4, 10 May 1991.

58. Interview between Linda Quirk and Kathi Moore, NPS Comptroller's Office, and LT Martin E. Jolly, 8 May 1991.

59. Freeman, Roger L., *Telecommunication Transmission Handbook*, 2nd ed., p.515, John Wiley & Sons, Inc., 1981.

60. Black, Uyless, *Data Networks*, p. 723, Prentice-Hall, Inc., 1989.

61. Stallings, William, *ISDN: An Introduction*, pp. 244-246, MacMillan Publishing Co., 1989.

62. Loescher, Machael S., CDR, USN, "Copernicus Offers a New Center of the Universe," *United States Naval Institute Proceedings*, pp. 89-90, January 1991.

63. Telephone conversation between Chuck Trigger, NCTC Code N43, and LT Martin E. Jolly, 22 November 1991.

64. Telephone conversation between Randy Lee, NCTC Code 43D, and LT Martin E. Jolly, 02 December 1991.

65. Telephone conversation between Tim Young, GSA, and LT Martin E. Jolly, 04 October 1991.

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