White Paper

A Report to the Office of Training Technology

Current and Future Capabilities of Desktop Videoconferencing (DVC)

by

Jeanie Dumestre

Naval Education and Training Program
Management Support Activity
6490 Saufley Field Road
Pensacola, FL 32509-5239

jeanie_dumestre@netpmsa.navy.mil

Robert M. Seltzer

Naval Air Warfare Center
Training Systems Division
12350 Research Parkway
Orlando, FL 32826-3224

robert_seltzer@ntsc.navy.mil

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I. INTRODUCTION

A. Background

The technology of room-based video teleconferencing (VTC) has been available within the Department of Defense (DoD) since the award of the Defense Commercial Telecommunications Network (DCTN) contract in 1985. The high cost of this network has been due largely to the relatively high bandwidth capability of its T1 communication channel (1.5 Megabytes/sec or 1.5 Mbps) used for transmission. This cost has limited accessibility of this technology to commands with high demand and large budgets that would justify the expense. As the demand for these sites has increased and new systems have been procured, the cost of room-based VTC has diminished to the point that most large military installations support access to some shared, room-based VTC network. However, as more command and service specific networks have become established, interoperability has become an issue within DoD. These VTC developments were paralleled worldwide, and the International Telecommunications Union (ITU), formerly called Comite Consultatif International de Telephone et Telegraphie (CCITT), took on the mission to develop VTC interoperability standards and encourage use of these standards by the manufacturers of the hardware and software. During the period of emerging room-based VTC standards, the development and use of personal computing became wide-spread. The advancements in compression technology that raised the quality of the room-based video signal and simultaneously reduced the effective communication channel bandwidth needed to transmit it, also made transmitting video more practical on the desktop or Personal Computer (PC). CODECs (stands for data compression coder/decoder hardware/software) were reduced in size and could now be put on boards inside the PC's. Along with these developments came the availability of the Integrated Services Digital Network (ISDN), which allowed lower purchase of bandwidth combinations for VTC and made it more functional on the desktop with less costly equipment. On the PC, conference participants could now not only see and hear each other, but could also share documents and make applications and comments accessible (referred to as whiteboarding) to all participants. Interoperability (primarily due to incompatible vendor proprietary CODEC's methods) once again became an issue with the introduction of a plethora of new PC-based hardware and software systems having Desktop Video Conferencing (DVC) capability. To address the problem, the ITU is continuing in the process to develop new standards to help further promote DVC interoperability.[M.1] The industry is also continuing to move forward to advance media bandwidth and the CODEC's capabilities.

B. Objective

The purpose of this report is to present an analysis of the state of DVC including current technology, its limitations, costs, and any projected near term (within two years) advances in this area of technology.

C. Scope

This white paper represents a “quick-look” synopsis of the current state and future trends regarding the technology elements of DVC, specifically addressing multi-point (as opposed to point-to-point) DVC. As such, the non-technical aspects regarding human computer interaction and social issues will not be addressed. Additionally, this paper is not intended to be a primer on desktop video conferencing, nor is it intended to be a highly technical description of the technology of DVC. Rather, the assumption is made that the peripheral issues associated with DVC (addressing the advantages of the technology, i.e., reduced travel costs, etc.) and the more technical aspects of DVC may be obtained by accessing the cited references. The applications of DVC will be discussed in the contexts of how they influence the DVC system technology requirements with specific emphasis on Navy requirements for DVC. Most of the research was done on the Internet, where information is updated frequently and thus reflects the most current state of the technology outside of obtaining hands-on experience with the actual DVC systems.

II. DISCUSSION

A. Requirements

The following application areas should be clearly understood before the DVC hardware, software, and communications specifications are defined. Both long term and short term DVC solutions must address at a minimum the requirements of interoperability, network compatibility, network access, and system side requirements.

1. Interoperability. Affects where (or with who), when (time of day), and for how long the DVC connection is made. Unless a private, internal network is established, [N.1] interoperability must be considered first and foremost. Knowledge of which specific sites with existing VTC capability need to be connected, and knowing which locations will need new systems to be connected will influence the rest of the requirements. It serves no purpose to have DVC capability if those you wish to connect to are not compatible with your system or with each other. Selecting standards based DVC equipment and software is the only way to assure the connection can be completed at the other end. The positive effect of driving DVC vendors to adopt standards can hopefully be accelerated by customers insisting/choosing standards based DVC equipment.

2. Standards There are a multitude of standards that address the different requirements of DVC interoperability. Each standard governs a different aspect of DVC operation. They are usually expressed using an alpha-numeric decimal notation such as H.nnn, where "n" is a number. With regard to DVC, the important industry standards are the ITU-T series **G** (addressing transmission systems and media, digital systems and networks), **H** (addressing line transmission of non-telephone signals), and **T** (terminal characteristics and higher layer protocols for telematic services, document architecture) Recommendations. It is useful to become familiar with standards terminology in order to specify compliance with certain standards when selecting DVC systems.

a. As reference [S.1] states, "teleconferencing standards can be divided into architecture and basic function standards. The architecture standards describe how the basic functions (video, audio, data, etc.) interrelate to form a teleconferencing system." As excerpted from reference [S.1], table B.1, contained in Appendix B, ("Related DVC Industry Standards") lists the architecture standards. Reference [S.1] also points out, that each of the architecture standards is associated with a particular type of communication link (i.e., ISDN, ATM, etc.). This information is also provided in table B.1. Also taken from reference [S.1], Table B.2 defines the relationships among the architectural and functional ITU-T standards. Table B.3 of appendix B, then provides a brief synopsis of the major standards along with their status.

b. The best way to have a chance at interoperability with other networks is to down select to only standards based systems. Even when standards have been accepted and implemented by the industry, unlike equipment is still not always interoperable. This is due to different interpretations and applications of some of the standards which were broadly written, as well as to different features each system might possess. As more standards are implemented, upgrades can be incorporated into a standards based system. This approach was taken with the Navy's video teletraining (VTT) network, and it remains one of the most flexible, interoperable networks in DoD today. Below is a list of the standards areas which are key to the future developments of DVC:

1) network interface(s), including switching, bridging
2) audio processing (usually) including decode, mixing, and re-encode
3) video switching
4) data processing
5) conference control and security
6) video compression
7) audio compression
8) miscellaneous like billing/accounting information, conference reservations, etc.

3. Video Quality. The quality of the video should allow viewers to recognize other conference participants. Being able to distinguish facial expressions should be a key video requirement for a DVC system. Without this requirement, an audio-graphics conferencing solution on the PC would provide all the other capabilities of DVC as a much less expensive solution. "The quality of a video is determined by a number of factors: screen size, number of frames per second (fps), and the image depth (colors). The current video standard is full screen size (640 x 480 pixels) and full motion (30 fps). H.261 is the standard recommended by the International Telecommunications Union, ITU-T that addresses video quality."[G.1] Additionally, the video standard for color is 24-bit. Other qualitative factors that come into play include video contrast, brightness and sharpness. Note, that current "talking head" shots are typically 100x100 pixels, with 8-bit color.[G.2]

4. Audio Quality. High quality audio is integral to DVC. Clearly, the absence of an audio signal makes DVC impossible. Actual Navy experience with room-based VTC systems has shown that under certain circumstances a conference could continue successfully with the loss of the video signal, as long as the audio is adequate. Audio quality can be assessed using the following four factors: integrity of tone, volume steadiness, distortion and noise, and overall clarity. Aside from these factors, overall video conferencing effectiveness can be seriously degraded if significant audio delays are exhibited.[D.1]

5. Bandwidth. The amount of bandwidth required for DVC depends upon the specific application feature requirements. Speech and video require significantly more bandwidth than data. The proportion of speech and video requirements to the data requirement must be considered. With regard to rendering the video useful on the desktop, it is preferred that the available bandwidth be able to support transmitting an image, scalable up to full screen picture size at the rate of 30 fps using a communication channel with a minimum bandwidth of 384 kilobits/sec or 384 kbps. A frame rate of 15 fps is minimally acceptable.

6. Transmission. The type of transmission required will depend on the bandwidth needed and the applications. For Department of Navy (DON), different types of transmission are available through government contracts.[N.1]

a. Multipoint video (connecting more than two sites during a conference) needs the timeliness and predictability of circuit switching, but it is not easily accomplished in circuit switched transmission today. "There are two major types of communication channels available to transmit the data: circuit- and packet-switched. Circuit-switched channels such as Integrated Services Digital Network (ISDN) offer dedicated bandwidth and predictable timing of data delivery but do not easily support multipoint communication. Packet-switched channels, either local area (LAN) or wide area network(Internet), more easily support multipoint communication but do not provide predictable timing of data delivery. DVC systems have requirements for timely data delivery and reliable data delivery. For example, audio and video data require timely delivery while other types of data, such as whiteboard data, require only reliable delivery."[G.2] Standard phone lines, switched 56-kbps lines, and ISDN, are circuit switched, dedicating the channel and the bandwidth between users or sites until the connection is broken by the users. While the connection is active, the bandwidth is dedicated to communicating between the conferencing sites and no other user in the system can make use of that bandwidth. Ethernet (LAN, WAN, Internet) communication channels share the total bandwidth among all the users who access it. The channel is designed to "switch" packets instead of circuits, where each packet is made up of between 128 and 4096 bytes each. Each packet is treated as an individual message, transmitted and managed by the network as a separate entity.[N.2]

b. Which method is better suited for video conferencing? The time it takes for one site to send a visual cue and the receiver to transmit a reaction back determines how interactive the application can be. Delays over three quarters of a second inhibit visual communication by disrupting facial cues and other fast reactions that people rely on in a real time, face-to-face meeting. If there is a heavy requirement for video, then circuit switched transmission, at the current time, would be more suitable than packet switched.[V.1]

7. Multipoint Capability. Point-to-point conferencing on the desktop can be accomplished with standards based DVC systems with little difficulty today. When more than two sites wish to conference, the lack of standards for switching equipment, or bridging standards makes this difficult. Multipoint capability is necessary for the live video portions as well as for the groupware. Multipoint conferences must go through a "bridge" or switching device. Money can be saved on switching devices at each site, if signals are sent to a central hub for switching.

8. Groupware Features. Compatibility with existing or planned user software and hardware should be specified. The ability to share applications and to collaborate on documents remotely is the real advantage DVC offers over room-based VTC. DVC programs offer four main ways to collaborate: whiteboarding, applications and data sharing, file transfer, and real-time text messaging (i.e., chatting). Because these capabilities can vary widely in their performance and be absent in some DVC products, it is important to define user requirements relative to these capabilities. These capabilities are further explained in appendix A. Application-sharing is a good example. Some programs provide simultaneous user editing capability, while others periodically send bit-mapped images, that can be seen by all participants but can be edited by only one. The type of applications and documents to be shared will also narrow the selection of the hardware and software. There are DVC systems for UNIX, IBM compatible, and Macintosh machines. Within the Navy, the platform of choice is expected to be mostly IBM compatible computers using Windows applications, i.e. Windows 3.1, NT, and 95, but some sites will also be UNIX and MAC platform based. Long term solutions should consider cross-platform compatibility, which is not expected to be realized until the next revision of the T-120 STD is implemented (1998 perhaps).

9. Scheduling. Scheduling is both a software and a management issue. DVC is often referred to as "dial-up" conferencing because it has been perceived to have the spontaneity of a telephone call. If the conference has not been prearranged, some sites may already be in use and will return a "busy signal." Who will do the scheduling and who will maintain connectivity information and site directories should be decided so the type of scheduling capability may be specified. There should be some type of scheduling software built into the DVC system to facilitate set up of and to keep track of conferences. There are also separate software packages that manage complex scheduling on busy networks. Some networks require that all reservation requests go through a central hub or scheduling facility.

10. Network or Site Management. The Policy or management issues of different networks and sites can affect the connection. The European Telecommunications Standards Institute (ETSI) has recognized the importance of the interface between network elements and network management systems in their telecommunications specifications.[S.2] Local policies for the system or network should be decided along with hardware and software requirements. Existing policies at potential connections should also be considered. Site priorities such as who uses it, for how long (session length), and for what type of use (e. g. training vs conferencing) may interfere with a connection just as surely as incompatible hardware. One controversy that has plagued the room based VTT and VTC communities is that although the technology used for both types of networks is the same, the way these networks are managed and operated is not. This is an important internal policy issue that can become an interoperability issue if it is not considered before setting up a system. Some conferencing sites limit scheduled sessions (meetings) to two hours so that many users may share the system. Some training sites schedule eight hour class sessions continuously and allow conferencing use only at lunch time or before and after classes. Trying to connect sites with such different policies may justify setting up additional DVC capability or the setup of another system at the site. Sometimes certain system functions are enabled or disabled to accommodate one type of use or site preference. In a conference with hundreds of participants, spontaneous questions would be unmanageable, but in a training setting with fewer participants this might be a highly desirable capability. Some networks are set up to require a chair control at each site, while some do not even enable this capability. Any consideration of using DVC for conferencing in the Navy should include connectivity to training as well as conferencing sites.

11. Cost. Cost today is largely a function of the bandwidth and the type of transmission utilized. Often more time is spent pricing the equipment and initial setup with little regard for the usage charge. How often the system will be used will determine whether use dedicated (bulk rate, like local telephone calls) or use sensitive (per time unit, like long distance telephone calls) purchase of the transmission is more cost effective. Cost benefit analyses and cost comparisons should be performed to determine which type of transmission and which bandwidth combination will be most cost effective. Reasonable usage estimates must be made to effectively compare costs, especially between use dedicated and use sensitive purchase of transmission. Cost for similar services differ among vendors, even on government contracts. If saving money by using DVC is not somewhere in the equation, then this element is not necessary.

B. Current Limitations

The difficulty with accomplishing DVC today is that one solution will not satisfy all of the basic requirements listed above. Some requirements and expectations must be compromised to implement DVC today.

1. Bandwidth The main obstacle to implementing high quality DVC at a reasonable cost is the high bandwidth requirement for an acceptable video quality. [G.1, G.3, G.4, G.5, M.1] There are two methods of mitigating/solving the bandwidth bottleneck problem. One solution is to use a communication channel with more bandwidth than a telephone line (often referred to as "POT" for Plain Old Telephone). Two such higher bandwidth channels are Ethernet and ISDN. The second solution approach is to utilize data compression techniques. Most DVC packages use a combination of these two approaches to varying degrees.

a. To illustrate the criticality of bandwidth requirements, consider that to transmit one second of standard video image of 640x480 pixels, (note most monitors support at least 1024x768 displays) at 30 fps, takes approximately 2 hours and 34 minutes to transmit using POTS (assuming 8Kbps) medium, 10 minutes using N-ISDN (N, stands for narrowband and assumes 128Kbps), and anywhere from 50 seconds to 3 ½ minutes for Ethernet (assuming 375Kbps to 1.5Mbps). Stated another way, with ISDN frame rates of 0.05 fps (or 1 new frame every 20 seconds) can be achieved and for Ethernet frame rates of 0.15 to 0.6 could be achieved.[G.4] Recall that our minimum DVC requirements for video transmission given in section II.A.d. is 15 fps and optimally 30 fps is desired.

b. To increase the frame rate from ISDN's 0.05 fps and Ethernet's 0.6 fps (optimistically) there has been a great deal of work done in the area of data compression. "How compression is performed really is of no interest to the average user. The important questions concern how well it performs, how it inter-operates with other companies' products, and how well it deals with operating on heavily loaded networks."[G.4]

c. A compression scheme is largely characterized by its compression ratio. The term compression ratio refers to a fraction that compares how large the data is compressed with how large the data is before it is compressed. Color space sampling and redundancy reduction are common techniques used in video compression algorithms. Without going into any further detail regarding compression schemes, (see [G.4] and [G.6]) for more details) consider again the video fps transmission rates achievable for the standard full screen (640x480 pixels or a 307 kbytes video frame image) illustration assuming a compression ratio of 1:10. With a compression ratio of 1:10 these numbers now become 2.5 fps and 1.5 to 6 fps.

d. Note that if a quarter scale image of 300x200 pixels is all that is required (not a standard full screen image of 640x480 pixels), then video image frame rates of 2.5 fps for ISDN and 7.5-30 fps for Ethernet are achievable, and it would appear that 30 fps video transmission is within reach. Unfortunately, the story is not complete. While the numbers above seem to remove the communication channel bandwidth bottleneck problem, they have in fact been moved to a different part of the system.[G.4] "Executing a compression algorithm takes time. Sometimes a lot of time. The higher the compression ratio, the longer the calculation takes. To achieve the frame rates given above hardware/software units called CODEC (which can be expensive) must be utilized."[G.6] To conclude this section, it's important to understand that the bandwidth limitations eventually impact interoperability in the sense that the need to use compression algorithms that can be intricate and require specialized hardware comes into play. Because of their complexity and the specialized hardware required in some cases, most vendor CODECs algorithms are proprietary. Proprietary algorithms can do this well (in most cases much better than the standard compliant approach since the least common denominator capable system is considered), but limits interoperability to sites using the same systems.

2. Standards This issue is the key to interoperability. It has spawned the formation of several groups who have tried to force a solution.[S.1-9] "Although the first Videoconferencing systems appeared in the 1970's, the technology is still bogged down by conflicting standards ... Before desktop Videoconferencing can become effortless and ubiquitous the problems of inter-connectivity and bandwidth have to be solved."[G.4] The ITU H.261, or Px64, specification for video compression was one of the standards that helped to bring about interoperability for room-based VTC. This standard is costly to implement because of hardware requirements, so it has not been embraced for DVC. The lack of standardization in desktop video protocols and equipment has led to a relatively slow rate of uptake in the technology..."[G.5] Just as it took time for the standards to emerge and be accepted in room-based VTC, so will it be for DVC.

a. Note, that some companies risk introducing a product quickly before the standardization process is complete, in order to get a jump on the market. In this case, if a company builds a compliant product while a specification is firm but not ratified, then there is the risk that the specification will change before being ratified. It should be noted that given the dynamic state of DVC standards, the truth is that many DVC products make claims to be standards compliant based on the emerging standards and not ratified ones. See Table B.3 for summary description of the major current and work-in-progress teleconferencing standards.

b. One of the latest happenings related to DVC standards was the announcement of 11 June 1996 by Microsoft Corporation and PictureTel Corporation indicating that they are submitting their jointly owned application sharing protocol to the ITU for consideration as a new component of the T.120 standard for interoperable data conferencing. According to the news release, "establishment of this protocol as an open international standard will allow two or more people to share applications simultaneously across the Internet, corporate, LAN's, or the public telephone network regardless of their hardware platform operating system."[S.10]

3. Interoperability Beyond the DON level, the problem with interoperability grows to satisfy Joint level and outside DoD compatibility. The main dilemma is the standard for bridging other networks to receive and transmit data. Without all of the above standards implemented to ensure true interoperability, DVC sites are currently limited to communications with sites using like equipment.[S.3] Even claiming to comply with all of the these standards does not assure interoperability. Some different interpretations of H.261 have created problems.[M.1]

C. Desktop Videoconferencing Systems

1. General Features. DVC systems consist of 4 primary subsystems. These subsystems consist of input and out put devices, system hardware and software, and video CODEC. Components are listed below.

a. Input and Output Devices

Input and output devices typically include:

1) Digital camera for face images
2) Second digital camera for other images
3) Microphone
4) Audio Device, such as speakers, headphones, or earphone for the sound capabilities. (Note, two products, CLI's Cameo and Visit Video for Windows from Northern Telecom Inc., use ordinary telephone for their audio output.[V.1])

b. System Hardware

1) Pentium based PC system with:
- 16 MB of RAM
- Microsoft Windows display driver running at 640x480x256 colors
- Graphical operating system, with window-techniques, for ProShare need MS Windows running in enhanced mode or Windows for Workgroups 3.11 Soundcard
- Network card
- Graphics card that supports DCI (if full screen video is required)
- 17 MB of free hard drive space

2) ISA bus for audio/video support (note, The ProShare Video system includes an ISA-bus digital interface card. On the board are two RJ-45 connectors, four stereo connectors: line in, line out, headphone, and microphone jacks; an S-VHS input and an RCA video input." [V.2]

c. System Software The system software determines the look and feel of the DVC product. It initiates the conference and usually includes interactive applications that enable file transfer and document sharing capability.[V.3]

d. Video Coder/Decoder (CODEC) Used to compress and decompress the large throughput of audio and video data transmitted over a network. CODEC can be implemented in hardware and/or software. Software CODECs tend to be less costly than their hardware counterparts, but carries the disadvantage of using PC processing time, which in turn generally requires a faster, more powerful PC platform. The Vivo320 system is a good example of this last statement (low cost, but best run on a Pentium platform; see table I).[V.1] As mentioned throughout this paper, compliance of a DVC system's CODECs to ITU Standard H.320 is critical to interoperability.

2. Cost. Basic DVC equipment can cost as little as $1,500 (see Table I for example systems), while room-based equipment begins in the range of $40,000. The two high cost items in any type of video conferencing, be it desktop or room-based remain the digital CODEC used for the video compression and decompression, and the bandwidth needed to transmit the compressed signal to and from sites. On the desktop, equipment costs can be reduced by using software to perform the compression and decompression of the signal. Transmission costs are another matter. A 384 kbps bandwidth, circuit switched transmission, or ISDN, use sensitive rate would cost about 3 times that of a long distance telephone call or about $1.50-$3.00 per minute. At $180 for a one hour call, the justification for this expense could only be made if the connection were to a room based system meeting where travel costs would have been incurred. Unfortunately, DVC technology cannot assure connectivity to room based systems today.

3. Vendor Product Summary.

Note: This Section is only available to Employee of U.S. Government Agencies upon electronic request to the OTT Webmaster.

D. Projected Near Term Technology Advances (Two Years)

Low-cost, PC-based videoconferencing over the Internet is becoming a reality. The emergence of public domain software, low cost cable modems, and small, inexpensive digital cameras will increase the demand for bandwidth and thus the market demands will continue to put pressure on the development of improved ways to realize greater bandwidth capability, and thus reduce the cost of procuring it.[M.1] "Until recently, networked multimedia applications have been based mainly on dedicated video conferencing rooms and video coders/decoders working via high-speed leased circuits or ISDN. However, the movement of multimedia to the desktop means that the applications are beginning to move into networks which were originally designed for more conventional data. This leads to the question of whether it will be packet, cell or circuit switched networks which will be used for the spread of multimedia."[G.4] "B-ISDN and ATM show promise for solving some of the problems encountered with both circuit- and packet-switched channels for desktop videoconferencing data. Emerging interoperability standards that allow systems to communicate with each other are also very important to the future of desktop videoconferencing."[G.2] Bandwidth and transmission developments will increase interest in DVC and perhaps influence more rapid development of standards.

1. Transmission Network Protocols and Media

a. POTS. According to Mike Pihlman, the newly approved H.324 Standard will pave the way for POTS DVC systems to become multipoint capable and interoperable. He goes on to say that this fact coupled with POTS low cost, may make it the dominant transmission path by the year 2000.[M.2]

1) High Digital Subscriber Line (HDSL). Asymmetric Digital Subscriber Line or ASDL and Symmetric Digital Subscriber Line or SDSL are the two primary types of HDSL's. SDSL is the more applicable technology to DVC and allows two-way bandwidth on the order of fractional T-1. Both ADSL and the newer SDSL are new high-speed modem technology that provides users with multimedia and high speed data communications capability through the use of existing twisted-pair copper telephone lines. ADSL provides a bandwidth of 6 Mbps (eventually up to 9Mbps) to a subscriber and around 640 kbps in return.[N.3] ADSL technology is based upon innovative algorithms and digital signaling processing to compress so much information through conventional twisted-pair telephone lines. "The main argument for the use of ASDL is that the infrastructure needed to support it, twisted-pair copper lines, is already in place, while a fiber/coax network cannot be distributed fast enough to competitively service the same markets for multimedia communications. A recent analysis of possible overhaul programs showed that fiber/coax cabling could not replace more than 21 percent of access lines worldwide by the end of the year 2000, thus leaving 79 percent (530 million lines) still in copper."[N.3]

2) "AT&T plans to offer three rate/distance combinations designed to address different remote-office-connectivity scenarios to include: (1) 160 kbps link running over POTS to be available at central-office-to-customer distances of up to 23,000 feet, (2) a 400 kbps service for central- office- to-customer distances up to 21,000 feet, and (3) 2.048 Mbps service for central-office-to-customer distances up to 8,000 feet."[N.4]

b. Ethernet -Packet Switched network "The packet switched connections, as used on the Ethernet and on the Internet, send the data in packages on not-predetermined routes. There is no permanent link between the participants. This allows a more effective usage of the bandwidth, but also means that at some points in time there are peaks and the packages arrive late. If traffic becomes heavy, multiple devices try to transmit at the same time, and packet collisions may result. If a collision occurs, all devices must re-transmit their data. This leads to even more collisions. For this reason most network managers consider 40 percent of total bandwidth to be the maximum available bandwidth over an Ethernet network. The risk of data-loss is also higher using this technology."[N.6] Once a package is lost, there can not be an error-correction like sending the package again (the video is already some frames ahead, unless there is a large buffer).[G.1] "It is a widely held belief that the Internet system does not have the reliability and consistent guaranteed quality required for business applications of multimedia. As a result, business users are more likely to pursue the ISDN solution with conventional video CODECs."[G.5]

1) Iso-Ethernet According to the March issue of Data Communications, the next advance regarding Ethernet technology is Iso-Ethernet.[N.7] Iso-Ethernet is a 16.144 Mbps technology ratified as a standard by the IEEE in the fall of 1995. "The Iso-Ethernet standard (IEEE 802.9a) sets aside 10Mbps for Ethernet traffic and 6.144 Mbps for isochronous (time-dependent) applications."[N.7] The 6.144Mbps is subdivided into 96 64kbps basic rate ISDN B channels and one 64kbps D channel for signaling control. Iso-Ethernet 's use of ISDN channels makes the connection to wide-area ISDN services a seamless one. Greenfield goes on to say that before the Iso-Ethernet is seriously considered, the hardware cost of adding iso-Ethernet adapters and hubs will have to decrease. Also at issue is the fact that installation can be difficult.[N.7]

2) Fast-Ethernet. "Fast Ethernet is a technology that provides 100bps bandwidth over traditional 10Base-T wiring, with the addition of new network interface cards. It is positioned as lower-cost alternative to higher speed technologies such as CDDI and FDDI."[N.8]

c. Integrated Services Digital Network (ISDN) -Circuit Switched network ISDN (or narrowband ISDN) using circuit switching- has been the favored mode of transmission for DVC because of the unreliability of packet switching of the video bit stream in real time communication. "In circuit switched connections, the connection is maintained throughout the sessions between the participating points. The advantage is that the bandwidth is available for the whole time. The disadvantage is that the required equipment, especially for multi-point connections, is very expensive."[G.1] Cost are expected to come down as more locations have access to ISDN and use increases. According to Mike Pihlman, "ISDN should be accessible almost everywhere in the Country by 1996."[N.9] Interestingly, the technologists at Zydecom have the following to say with regard to the future of ISDN:

> Zydecom believes that the future of multimedia communication lies in the establishment and operation of local and regional Intranets. Where the Internet is a free information road replete with pot holes, new construction, and even dirt roads, these Intranets will be very efficient, well maintained, high-speed toll roads. Access to the Intranets could come in many forms. Zydecom believes that the future access methods will be in the telephone companies new XDSL (X digital subscriber lines, where X can be either Asymmetric, Symmetric or High-speed), cable modems, or high-speed wireless. Your normal telephone line will have much higher speed capability than it does today, and the Integrated Services Digital Network (ISDN), once thought to be the communication service of the future....will go away. [M.3]

d. Broadband ISDN. Broadband ISDN or B-ISDN, distinguishes itself from ISDN (frequencies <4000Hz) by the fact that ISDN uses the copper wire medium (the local or subscriber loop, i.e., the last 1.6 km or so of 22-26 gauge copper wire) already in place, whereas B-ISDN uses the "newer, better, cheaper, and faster" fiber optic technology.[N.10] The emerging broadband ISDN (B-ISDN) will support transmission faster than 2Mbps, up to an as yet unspecified rate. The time frame for availability of B-ISDN appears to be much greater than 2 years.[N.11]

e. ATM. Asynchronous Transfer Mode (ATM) is a service that can run over B-ISDN and is literally little more than the specification for a 48-byte packet or cell of information with a five-byte header which tells the telephone system where the packet is going.[N.10] ATM seems to be the long-term (5 years) solution to the bandwidth problem for DVC, but it is currently beset by lack of standards and high costs.[N.2] It is expected that ATM will eventually be the standard for transporting multimedia data communications in both the local and wide areas.[N.12] The Army plans to migrate all of their VTT systems to ATM by the year 2000. "The other challenge to ISDN and circuit switching comes from Asynchronous Transfer Mode (ATM) which many regard to be the perfect network technology for multimedia. Once there is a requirement for real time video and bandwidth-on-demand, there is a requirement for ATM because it allows the flexible satisfaction of peaks in bandwidth demand. However, there are many more technical challenges facing the developers of ATM in terms of, for example, interoperability between WAN switches, as well as the reduction in cost per bit of an ATM connection, which at the moment is prohibitively expensive."[G.4] Future DISA government contracts will include ATM transmission.[N.1] Costs are expected to come down by the year 2000 as standards for this newer technology begin to emerge and use increases.

f. Multicast Backbone (MBone). To better utilize the limited bandwidth of the Internet, a technique for UNIX machines, the MBone (pronounced "M" bone) was devised by the Internet Engineering Task Force in 1993 for the purpose of performing videoconferencing on the Internet. "MBone is a virtual network on top of the Internet and it allows multiple addresses per packet of data, so that instead of having n-streams for n-participants, there is only one stream of data, since a recipient will copy the data and send it to the next participant."[G.1] The MBone can be implemented as a network subset of the Internet by using the Intelligent Peripheral (IP) multicast protocols to provide multicast video, audio and shared whiteboard facilities across the Internet. "MBone provides multi-point connections, either one-to-many or few-to-few, while preserving Internet bandwidth by making use of multicasting. They are freely available on the net."[G.3] "Currently there are about 2000 MBone-using sites, and the MBone itself is doubling in size every six months or so."[N.13] The major disadvantage for adopting this method for DVC is the requirement for a "heavy-duty" UNIX workstation and a T-1 line to get started on video (a 56kbps line suffices if audio is the only requirement). Because of these limitations, this approach to DVC does not rank as a highly viable option. More information regarding the MBone (and the software needed) can be found on the WWW at reference [N.14].

g. Hybrids. Since many office workstation setups include LAN connections, it is likely that DVC connections will be hybrid.

> Most data terminals are already connected to local area networks (LANs), so it is possible that LANs will be the basis for transmission of multimedia around a single site. These will probably use ATM and a dedicated Ethernet to the desktop. This means that if the users have LANs, there will not be a need for ISDN which has really been derived from voice communications. The only argument in favor of ISDN is the unreliability of packet switching of the audio and video bit stream in real time communication, but this concern has been refuted by recent developments in the area. In terms of the network, there have been key developments, e.g., IP Multicasting Protocol (which allows audio and Videoconferencing between hundreds of participants) and the Real Time Protocol (which improves the functionality of multimedia conferences on the Internet). Multicasting allows a single multimedia stream to be sent to more than one destination without the need for a dedicated channel to each one. However, it is a widely held belief that the Internet system does not have the reliability and consistent, guaranteed quality required for business applications of multimedia. As a result, business users are more likely to pursue the ISDN solution with conventional video CODECs. [G.4]

h. Cable Television Transmission. This network is not burdened by bandwidth limitations, so some experts expect this to be a long term solution for DVC and telecommuting. Additionally, the use of ATM over these networks would permit cable operators to allocate bandwidth based on customer usage and there specific bandwidth needs.[N.15] Currently, the cable network’s capability for return communication is limited (the network has been designed as a distributed network composed of a trunk and branch topology where the source signal goes through 40 cascaded amplifiers on route to its destination), the networks are generally proprietary, and are not connected together. An early 1996 technology innovation in two-way cable modems appears to be a viable solution to the one way communication limitation.[N.15] For example, the Motorola CyberSURFR cable modem advertises modem speeds of up to 30 MBPS in the downstream path and up to 768 Kbps in the upstream path. [N.16] However, it must be kept in mind, "that the end-to-end data transfer rates on the Internet usually do not exceed 1.5 Mbps. So no matter how fast a cable modem itself can go, 1.5 Mbps is the top effective speed limit on the information highway; secondly, and even more problematic, is the fact that the Internet is having difficulties adjusting to the current increase in demand from low-speed traffic (dial-up modems)." [N.17] This will allow the cable industry to tap into what is currently a telephone network market. The cable networks throughout the country have been able to take advantage of newer transmission technologies and have already installed fiber optics in many communities. This competing ability to reach so many telephone customers will help reduce costs and make "dial up" DVC a reality. Of course the standards battle has yet to be fought in this arena.[N.18]

i. Wire-less Transmission. Local Multipoint Distribution Service (LMDS) and Mutichannel Multipoint Distribution Service (MMDS) are wireless technologies that are competing against their wired (and satellite) counterparts. Current systems are based on analog (FM) transmission, but is quickly giving way to the next generation of digital systems. The major players in the advanced LMDS market include Motorolla, HP, TI, Lockheed-Martin, and ADC, while some of the smaller players include VideoPhone and Stanford TeleCommunications. The current price range of wireless modems is $300-1,200 or more. Wireless modems produced by Hybrid Networks, have demonstrated bandwidth capacities of 10Mbps.[N.19] Once again though, wireless access to the Internet is plagued with ITS inherent bandwidth limitations. Overall, it appears that wireless modem access technology is on a 5 year maturity track, and its ability to make inroads into the wired market seems questionable in the near-term.

2. Data Compression Technology

According to Dejesus, "New compression tools, such as wavelets or fractals, will find use in Internet broadcasting (see News & Views, December '95, page 34.[N.20] Microsoft and Intel are reportedly using wavelet technology in their respective "Blackbird" and Indeo products. Some research projects have produced nearly 500:1 compression of video, but not in a commercial product -- yet. Since compression techniques continue to change and improve, it is important to retain the flexibility afforded by software-only solutions."[N.21] Another potential technology breakthrough that has been reported in this area is by a company called Knex in Fremont, California. “Knex is developing a radical new compression scheme that can send 320 x 240 pixel color images at 15 fps over telephone systems with a transmission delay of less than 200 milliseconds."[G.4]

E. Organizations to Watch For New Developments

These groups are responsible for ultimately bringing interoperability to the desktop. Their websites (listed in the reference section) contain the latest information on the development and implementation of DVC standards.

1. International Telecommunications Union (ITU). The ITU is a body of the United Nations that focuses on developing standards like the ones described in appendix B. One branch of the ITU, the Telecommunication Standardization Sector (ITU-T) is concerned solely with developing telephoney (see Appendix A for definition) standards. This is the group responsible for the interoperability of video conferencing worldwide. The standards are developed within the ITU-T by fifteen Study Groups that are divided by broad telecommunication's categories. Each study group includes several Work Parties, which are further broken down into Questions that address specific issues. The Questions are comprised of industry experts whose time and expertise are contributed by their respective companies. Editors within the Questions generate the original documents proposing new standards.[S.7]

2. International Multimedia Teleconferencing Consortium (IMTC). The IMTC is a non-profit corporation established to promote the creation and adoption of international standards for multipoint document and video teleconferencing. The IMTC and its members promote a "Standards First" initiative to guarantee interworking for all aspects of multimedia teleconferencing.[S.2] The merger of The Consortium of Audiographics Teleconferencing Standards, Inc. (CATS) and The Multimedia Communications Community of Interest, (MCCOI) formed the IMTC. CATS and MCCOI were both formed in 1993, CATS to help create and promote international standards for multipoint audiographics teleconferencing, and MCCOI to accelerate the acceptance of desktop multimedia collaborative applications worldwide and to promote the use of open standards for Interoperability. CATS has centered on and succeeded in mobilizing industry support for the ITU-TSS T.120 standards suite worldwide. MCCOI has concentrated efforts on the ITU-TSS H.320 standards suite. "The IMTC therefore integrates and unifies the efforts of two leading organizations in the standards area, and establishes a strong global presence in the process."[S.6]

3. European Teleconferencing Federation (ETF) The ETF was formed to promote teleconferencing by playing a key role in raising the profile of teleconferencing and supporting central market initiatives. This group showcases new technologies, hosts videoconferencing events, and collaborates on major industry research projects. The ETF also publishes a newsletter, available through their web site. The ETF plans to publish a major industry guide to teleconferencing, which will include: a full directory of users and suppliers, a directory of dial-up videoconferencing sites, technical information, a glossary of terminology, a guide to teleconferencing bodies around the world, and case studies showing the business benefits.[S.11]

4. Information Society Initiative (ISI). The ISI partnership between British industry and Government was formed by the Department of Trade (DTI) in February, 1996, to promote the beneficial use of information and communications technologies in the UK. By advancing the effective use of information and communication technologies, ISI intends to initiate a range of business, social and economic benefits. It will make money available, in the form of grants and awards and provide support for innovative companies and projects through the year 2000. One expected product is a set of ISI implementation guides to furnish in-depth briefings on the use of technologies and how apply them to businesses use.[S.12]

5. Multimedia Communications Community of Interest (MCCOI or MCCI). The MCCI was a consortium of European, North American and Asia-Pacific carriers and vendors including IBM and Northern Telecom Ltd., formed to collaborate on video teleconferencing standards.[G.5] They have merged with The Consortium of Audiographics Teleconferencing Standards, Inc. (CATS) to become the IMTC.[S.6]

6. Personal Conferencing Work Group (PCWG). The PCWG was established in 1994, "to create specifications for interoperability across multiple communication infrastructures."[S.8] The group's membership consists of more than 180 international computer and telecommunications companies. Having recognized goals similar to those of the IMTC, this group has merged into the IMTC.

III. CONCLUSIONS.

There are numerous DVC hardware and software solutions, at variable quality and cost, to bring Videoconferencing technology to the desktop, however in our opinion DVC is not ready to replace the telephone for multipoint worksite collaboration. It is currently best suited for one-to-one (i.e., point-to-point) or one-to-few conferencing. As with all technology, anything can be accomplished for the right price. Standards are the key to making the technology affordable and accessible for everyday use. Desktop conferencing standards are still emerging, so that interoperability, between different desktop systems and between desktop and room-based conferencing systems, is not easily accomplished. Current DVC technology has some advantages over room-based VTC. It can be accomplished at the work site, and it is more interactive. By taking advantage of the capabilities of the MAC, PC and workstation technology, participants can collaborate on and share documents, applications, note taking, and white board comments. While room-based VTC is more compatible for a large number of participants, DVC is limited in the number of participants who can effectively and efficiently collaborate on the same documents. While some DVC systems can be set up and operated at a lower cost than some room-based systems, it does not necessarily follow that DVC is cheaper than room-based VTC. Requirements drive the cost of any system, so comparisons should be made among systems based on those requirements. DVC can best be accomplished today in the private network setting. Dialing up *any colleague* on a computer instead of on a telephone is more than two years away from realization.

A. These conclusions are supported by an excellent reference published by the Institute for Defense Analyses (IDA), entitled, “Analysis of Standards and Products for Desktop Teleconferencing,” January 1996. Additionally, they concluded that, “in the critical area of teleconferencing from workstations on LAN’s, it is likely to be several years before a market dominating technology is identified.”[S.1]

B. DON has used room-based VTC solutions to meet its large group conferencing and training needs. However, quantifying the cost effectiveness of video conferencing and training is difficult relative to other more typical Navy training systems (i.e., simulators, Interactive course ware, etc.). The cost effectiveness of a training system has been easier to quantify than that of a conferencing system, because students would have been given the training in some other way. In conferencing, more people may attend the meeting remotely than would have if travel to the meeting were involved. Using a room-based VTC system to solve a small population's training and conferencing needs is not always cost effective. At some Navy locations where the user population is too small to make accessing these networks cost effective, DVC solutions have been investigated. Often the expectations are high and the knowledge is limited concerning what system specifications would meet the user's needs. The images of dialing from the desk into a remote meeting to participate without traveling to the site, or into other remote desktops needs a reality check. The site at the other end of the "dial" must have the same capabilities or it will not happen. Often users let specific DVC product features drive their interest in a particular system, rather than letting their user defined requirements find the system that most fully meets their needs. This major mistake is made because users do not take the time to define their requirements and determine if there is a DVC solution.

C. One Navy technology vision at the start of the CESN VTT network was to eventually connect sites too small to support the 800 students/year needed to justify the cost of a room based system. One way to do this would be to have several DVC work stations in each Navy learning center. These DVC stations would be able to connect to room based network courses. At a small site, where few sailors require the same course at the same time, several could go to the learning center and "tune in" to whichever course was required. All might be taking the same course, or each a different one. This connectivity would also be accomplished to other training networks as well as to conferencing networks. These DVC stations would also be available for small site conferencing needs. Individuals needing to travel to a meeting, especially in Washington, DC, could participate remotely by requesting that the meeting be held in a VTC room. Upper echelon personnel who needed to travel frequently to meetings could connect directly from their desktops. However, until all the standards issues for network, equipment, and software, are agreed upon and incorporated, this vision cannot be realized. Our technology group will continue to watch for new developments to support this concept.

IV. RECOMMENDATIONS

If one were to consider setting-up a DVC system today, the following recommendations are made:

Set up a private DVC network using ISDN and the most standards compliant system that meets your application needs;

Expect to upgrade or replace system periodically as the new standards are available.

Recommendations stated in reference [S.1] concur with the results of our latest research and stated here verbatim:

“**Recommendation 1:** Adhere to the adopted DoD profile for video teleconferencing where the bandwidth can support it.

Recommendation 2: Even when profile requirements can be met, wherever feasible, acquisitions should be delayed until the T.120 standards are incorporated into the products and the profile

Recommendation 3: Proprietary solutions should be considered only where the benefits outweigh the cost of throwing them away, in some cases as soon as one or two years from now.

Recommendation 4: Avoid major investments in teleconferencing products that do not support clear market-leading standards.” [S.1]

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[S.4] International Multimedia Teleconferencing Consortium (IMTC) Press Release, "Industry Leaders Conduct Interoperability Tests for Data Conferencing, " March 27, 1996, <*http://www.sni.net/imtc/event120pr.html*>.

[S.5] Russell, Glenn, International Multimedia Teleconferencing Consortium (IMTC) Home Page, "ITU-T H.320 Standards For Video Conferencing," December 28, 1995, <*http://www.sni.net/imtc/*>.

[S.6] International Multimedia Telecommunications Consortium, Inc. (IMTC), "Questions and Answers," accessed July 2, 1996, <*http://pec.etri.re.kr/MMTC/imtc/qanda.html*>.

[S.7] ITU WWW Homepage, accessed 11 June 1996, <*http://www.itu.ch/index.html*>.

[S.8] Personal Conferencing Work Group (PCWG), "About Personal Conferencing Work Group," accessed July 2, 1996 <*http://www.gopcwg.org/about*>.

[S.9] Peeters, Frank, "Telecommunications Management Network - Major Characteristics and Architectural Elements," accessed July 4, 1996, <*http://www.etsi.fr/ecs/reports/stateart/peeters.htm*>.

[S.10] WWW Homepage, "PictureTel News Release," 11 June 1996, <*http://www.picturetel.com/global.htm*>
==> Microsoft and PicureTel submit application-sharing protocol to ITU for

consideration as global standard.

[S.11] European Teleconferencing Federation (ETF), accessed July 2, 1996, *<http://w3.win-uk.net/~mmtech/etf/etf-news/17/headlines.htm#directory>.*

[S.12] Information Society Initiative (ISI) "Introduction," accessed July 2, 1996, *<http://www.isi.gov.uk/introisi/introisi.html>.*

[S.13] Hendricks, Charles, "Section2: Taking a Stand on Video; Overview of Videoconferencing Standards," accessed June 3, 1996, *http://www.bitscout.com/FAQBS2.HTM>.*
==> Addresses the following questions: (1) What is H.320, H.321, H.323, H.324, H.242, H.221, H.222, (2) What are the T-120 series, (3) What is H.261? Is H.261 lossless compression?, What is the difference between Indeo and H.261?

[S.14] Phillips, Shayne, "Weclome to the Interesting World of Standards," latest update 12 May 1995, *<http://sa.comtech.com.au/shayne/vconf2.html>.*

[S.15] International Telecommunications Union, "ITU-T Recommendations," last updated July 10, 1996, *<http://www.itu.ch/itu-t/rec.html>.*
==>provides links to all the ITU-T series of recommendations (i.e., G, H, T series).

[S.16] International Telecommunications Union, "List of ITU-T T-Series Recommendations in Force," last updated 27 May 1996, *<http://www.itu.ch/itudoc/itu-t/rec/t/listrect_e_4271.txt.html>.*

[S.17] International Telecommunications Union, "List of ITU-T H-Series Recommendations in Force," last updated 27 May 1996, *<http://www.itu.ch/itudoc/itu-t/rec/h/listrect_e_4304.txt.html>.*

[S.18] Pilla, Louis, J. "Industry Profile for Video Teleconferencing," Defense Information Systems Agency Joint Interoperability and Engineering Organization Memorandum, May 1995, *<http://bbs.itis.disa.mil:5580/E6754T2882>.*

[S.19] "Cos Industry Profile for Video Teleconferencing," Defense Information Systems Agency Joint Interoperability and Engineering Organization, *<http://bbs.itis.disa.mil:5580/E4284T2882>.*

*[S.20] “Links to H.320 Compliant Products,” accessed June 20, 1996, *<http://www.terena.nl/projects/device/databank1/h320.html>*
==> provides list of H.320 Compliant DVC COTS products. Additional info on DVC product interoperability can be found at web address <http://www.terena.nl/projects/device>.

[S.21] Davis, Andrew, W., "Face to Face: Videoconferencing Systems from Different Vendors Can Now Talk to Each Other, Thanks to a Standard Called H.32X," Byte

Magazine, October 1995, <*http://www.byte.com/art/9510/sec7/art1.htm*>
==> Good technical description of H.261 video compression algorithm.

[S.22] International Multimedia Teleconferencing Consortium (IMTC), "ITU-T H.320 Standards For Video Conferencing," accessed May 29, 1996, *http://www.sni.net/imtc/>.*

[S.23] International Multimedia Teleconferencing Consortium (IMTC) "T.120 Standards for Audiographic Teleconferencing," accessed July 3, 1996, <*http://www.sni.net/imtc/t120.html>.*

[S.24] Schaphorst, R., Rapporteur, "ITU-T Recommendation H.263," November 1995, <*http://www.nta.no/brukere/DVC/h263_wht/>.*

[S.25] "Overview of Formal Telecommunications Standards Organizations," Communications Standards Review, March 10, 1996, <*http://www.csrstds.com/stdsover.html>.*

[S.26] European Telecommunications Standards Institute (ETSI) "Home Page," accessed July 4, 1996, <*http://www.etsi.fr/>.*

[S.27] "CCITT Standards," Desktop Video AGOCG Report, accessed July 3, 1996, <*http://www.agocg.ac.uk:8080/agocg/PrevPj/Desktop/report25_10.html*>
==> Good CODECs discussion.

E. Vendor System Products (V)

[V.1] Taylor, Kieran and Kevin Tolly, "Desktop Videoconferencing: Not Ready for Prime Time," Data Communications on the Web, April, 1995, <*www.data.com/Lab_Tests/Desktop_Videoconferencing.html*>
==> Evaluates the following five systems: (1) Compression Labs Inc., Cameo Personal Video System, (2) Intel Corp., Proshare Video System 200, (3) Northern Telecom Inc., Visit Video for Windows, (4) Picturetel Corp., PCS 50, and (5) Vivo Software Inc., Vivo 320.

[V.2] Pihlman, Mike, "Videoconferencing Table," accessed June 28, 1996, <*www.hyperstand.com/SITE/Awesome/vidconf/table.html>.*

[V.3] Hewitt, Kathy, "Desktop Videoconferencing Products," May 21 1996, <*http://www3.ncsu.edu/dox/video/products.html>.*

[V.4] Garland, Eric, and Dave Rowell, "Face to Face Collaboration," Byte Magazine, November 1994, <*http://www.byte.com/art/9411/sec10/art1.htm>.*

[V.5] "What's New: Four-Way Videoconferencing," Byte Magazine, April 1995, <*http://www.byte.com/art/9504/sec16/art3.htm>.*

[V.6] Byte Magazine, May 1995, *http://www.byte.com/art/9511/sec9/art12.htm>.*
[V.7] “In Your Face,” Byte Magazine, October 1995,
<http://www.byte.com/art/9510/sec7/art2.htm>
==>2-page article highlighting to ISDN choices (Intel’s Proshare, PictureTel Live PCS 100, Vivo Telework-5, Apple’s Quicktime, as well as POTS choices.

[V.8] Seachrist, David, "Virtual Whiteboards," Byte Magazine, November 1995,
<http//www.byte.com/art/9511/sec9/art12.htm>
==> looked at 7 DVC systems: (1)AT&T Visitium (has since been discontinued), (2) Crosswise’s Face-to-Face, (3) Invision, (4) PictureTel’s LiveShare Plus (5) IBM’s Person- to-Person, (6) Intel’s ProShare Premier Edition, and (7)TalkShow. PictureTel’s LiveShare Plus was s their clear winner for its ease of use, feature versatility, and performance. Second and third choices were the Intel ProShare Premier Edition, and Future Labs’ TalkShow. This article also has a very good discussion of conferencing basics and what to look for in a DVC system and detailed product comparison data.

[V.9] Pihlman, Mike, WW Homepage, "Desktop Videoconferencing," September 1995. (note, also published in November 1995 issue of NewMedia Magazine),
www.hyperstand.com/SITE/Awesome/vidconf/main.html>.
==> presents reviews of the following systems: (1) Apple QuickTime Conferencing, AT&T Visitium 1300 (has since been discontinued), (3) Compression Labs’ Cameo, (4) Creative Labs ShareVision PC3000, (5) Intel ProShare 200, (6) PictureTel PCS 50, (7) RSI Eris, (8) VIC Hi-Tech Global Phone, and (9) Vivo320.

[V.10] Leeds, Mathew, "Desktop Videoconferencing," MacWorld Magazine, November 1994, *<www.macworld.com/q/november.94/Feature.984.html>*
==> tested four systems available for the Mac: (1) Cameo personal Video System from Compression Labs, (2) Connect 918 from NUTS Technologies, (3) ShareView 3000 From Creative Labs, and (4) Visit Video from Northern Telcom.

[V.11] McClelland, Deke, "The Video Connection: Videoconferencing--Desktop Fact or Fiction," MacWorld Magazine, May 1996,
<www.macworld.com/q/@794104ttrbjm/pages/may.96/Feature.2022.html>
==> Mac World tested four systems over ISDN: (1) Apple’s QuickTime Conferencing Kit, (2) Sat Sagem’s Meet-Me, (3) Northern Telcom’s Visit Video 2.0, and (4) RSI Systems’ Eris. Editor’s choice was the Eris.

[V.12] “Desktop Videoconferencing: Candid Camera,” PC Magazine, 25 April 1995,
<http://www.pcmag.com/issues/1408/contents.htm#UPF>
==> PC Magazine lab tested 11 systems to help determine which system might be suited to your needs and budget.

[V.13] SSA-Softwight WWW Homepage, 22 July 1996, *<http://www.softwright.co.uk/>.*

[V.14] WWW Homepage, "Semiconductor News Business and Technology Brief," 15 May 1996, *<http://206.43.192.113/news/1996/596/misc/tech.htm#16.*

[V.15] CHIP Talk, "Zoran, DSP Collaborate on New Video-Conferencing Chip Design," accessed June 20, 1996, *http://206.43.192.113/news/1996/596/misc/zorandsp.htm>.*

[V.16] Pihlman, Mike, "Videoconferencing Scorecard" accessed June 28, 1996, <*www.hyperstand.com/SITE/Awesome/vidconf/score.html*>.

[V.17] Godbole, Ashish and David R. McGee, "ProShare Personal Conferencing Video System: an Evaluation of Technology in Distance Learning," March 1, 1996, <*http://www.cse.ogi.edu/~dmcgee/cse564/project.html*>.

[V.18] Hendricks, Charles, "Section 4: Video Guts; Videoconferencing Hardware, Software, and Vendors," accessed June 12, 1996, <*http://www.bitscout.com/FAQBS4.HTM*
==>addresses the following questions: (1) What are some cameras, (2) What are some MCU vendors, (3) what are some system vendors, (4) details regarding PictureTel products as well as some others.

[V.19] Staff, Data Communications Magazine, "The 1996 Data Communications Market Forecast," March 1996 issue, h*ttp://www.data.com./Roundups/1996_Market_Forecast.html*>

[V.20] Fawcetts, Sue, and Suzanne Runnels, Videoconferencing," last updated 12 June, 1996, <*fiat.gslis.utexas.edu/~sfawce/Newintropage.html*>.

[V.21] Labriola, Don, "Multipoint Conferencing is Real," PC Magazine, 27 November 1995, <*http://www.pcmag.com/issues/1421/pcm00188.htm*>
==> Addresses MCU's and associated costs, and brief eval. using the PictureTel

APPENDIX A

Glosssary of Defined Terms

Note, more comprehensive listing of related Glossary terms can be found at the WWW sites of references [G.15]-[G.18].

ATM - Asynchronous Transfer Mode. ATM is a connection-oriented network service. It is a high-bandwidth, fast packet switching and multiplexing technique that segments packets into 53-byte cells. It supports sound (voice and audio), data documents (text, graphics, and still images), and video (moving pictures with sound) ATM and Synchronous Digital Hierarchy (SDH)/Synchronous Optical Network(Sonet) are key technologies enabling broadband ISDN. Connection speeds on ATM networks are expected to reach 10Gbps this year.[N.11]

coaxial - a high capacity cable used in communications and video, commonly called coax. It contains an insulated solid or stranded wire that is surrounded by a solid or braided metallic shield wrapped in an external cover. Coax provides a much higher bandwidth than twisted-pair wire.[G.18]

Ethernet- Ethernet LAN's operate over twisted-pair wire and over coaxial cable at speeds up to 10 mbps. The theoretical limit of Ethernet, measured in 64-byte packets is 14,800 packets per second. By comparison Token-Ring's limit is 30,000 and FDDI's is 170,000 packets per second.[G.18]

Frame Rate - the number of still images that are displayed every second. Television displays at 30 frames per second.

Fiber distributed data interface (FDDI)- a 100 mbps networking scheme for fiber-optic LANs.[G.18]

ISDN - Stands for Integrated Services Digital Network. Is a set of Digital transmission protocols defined by the International Telecommunication Union (ITU) and is accepted as a communication standard worldwide, and has a large installed base in Europe. ISDN consists of B (bearer) channels for voice, data and other services and one D (delta) channel for control and signaling information. Basic rate interface (or BRI) ISDN consists of two 64-kbps B channels and one 16-kbps D channel. Primary rate ISDN consist of 23 B channels plus one 64-kbps D channel in the United States, 30 B+D channels in Europe. According to reference [N.11], the emerging broadband ISDN (B-ISDN) will support transmission faster than 2Mbps, up to an as yet unspecified rate. ISDN lines can transmit voice, data, and images simultaneously over existing telephone lines. Although ISDN service is now available in most of the U.S., it is limited to certain areas within each state.[N.11] ISDN channel bandwidth is 128 kbps (characteristic of basic rate interface (BRI)ISDN or often referred to as Narrow band N-ISDN or just ISDN for short) over regular phone lines.

Multipoint Control Unit(MCU)- a sophisticated multiport device that assembles three or more point-to-point videoconferencing systems for a multipoint conference[G.18]

Multi-point Conference -A conference that connects three or more nodes

Point-to-Point conference -A conference that connects two nodes.

T1+ Fractional T1 - T1 and Fractional T1 leased lines are essentially private reserved pathways (or pipelines) through the service provider's network that are "rented" by the user to carry traffic. T1 lines provide 1.544 Mbps of bandwidth, which is typically divided into 24 channels of 64 kbps each. Typical Fractional T1 rates are 128kbps, 256 kbps, 384 kbps, 512 kbps, and 768 kbps. Connection to the bnetwork requires the appropriate data or voice equipment (such as a router or T1 multiplexer), and a CSU/DSU to provide the actual interface to the network. T1/FT1 pricing is comprised of a fixed base and a mileage-sensitive component[N.38] As pointed out by reference [V.1], Fractional T1 lines can be a costly option that does not provide multipoint connectivity.

Telephoney - Equipment and systems used to integrate computertechnologies with telecommunication networks.

Twisted pair - (a) two insulated copper wires twisted around each other to reduce interface between the wires. This is currently the most common type of transmission media, but twisted pairs have less bandwidth than coaxial or 100Base-VG, (b) an Ethernet in which the physical medium is an unshielded twisted pair capable of carrying data at 10mbps for a maximum distance of 185 meters.[G.18]

Whiteboarding - is the term used to describe how DVC participants can share "editing" annotations on the current shared page. Because Whiteboarding is performed in a graphical environment the usefulness of this feature is determined by a product's ability to import (i.e., using print capture, or import filters) the graphics into the whiteboard mode. Note, that the number of file types supported by the various import filters does vary. Whiteboarding image editing features that can be very useful include: (1) zoom in/out, (2) screen refresh (refreshes all participants screens), and (3) page sorters (provides miniature page viewing mode to allow for browsing and easier moving of document pages).

Appendix B

Related DVC Industry Standards

Table B.1 Teleconferencing Architectural Standards[S.1]

Number	Title	Comm. Link	Status
H.310	Broadband Audiovisual Communications Systems and Terminals	ATM	Draft
H.320	Narrow-band Visual Telephone Systems and Terminal Equipment	ISDN	Adopted (Mar. 1993)
H.321	Adaptation of H.320 Visual Telephone Terminals to B-ISDN Environments	ATM	Draft
H.322	Visual Telephone Systems and Terminal Equipment for Local Area Networks which Provide a Guaranteed Quality of Service	LAN's	Draft
H.32Z.2 (H323)	Visual Telephone Systems and Terminal Equipment for Local Area Networks which Provide a NonGuaranteed Quality of Service		Draft
H.324 [1]	Terminal for Low Bitrate Multimedia Communication systems and Terminals	POTS and Analog Modems	Adopted (Nov. 1995)
T.120 [2]	Transmission protocols for Multimedia Data	runs on PSTN, ISDN, CSDN, PSDN, B-ISDNs, LANs (ref [S.12])	Balloting

[1] H.324 is the latest architecture standard approved

[2] Note, T.120 is both an architecture standard and a function standard. It is an architecture standard for audiographic teleconferencing, but also serves as the data component standard for VTC architectures that incorporate data.. That is, the infrastructure functional recommendations of T.120 are designed to be compatible with the architectural standards, but can stand alone when video is not needed. [S.1]

Excerpted from reference [S.1] Table B.2 below defines the relationships amont the Architectural and functional ITU-T standards

Table B.2 Relationships Among Architectural and Functional Standards[S.1]

	Architectural Standards					
Functional Standards	H.310	H.320.	H.321	H.322	H.32Z.2 (H.323)	H.324
Video	H.261, H.262 (MPEG-2)	H.261	H.261	H.261	H.261, H.263	H.263
Audio	G.7xx, MPEG-1, MPEG-2	G.711, G.722, G.728	G.711, G.722, G.728	G.711, G.722, G.728	G.711, G.722, G.723 G.728	G.723
Data	T.120	T.120	T.120	T.120	T.120	T.120, T.434, T.84, Others
Miltiplex	H.222.1, H.221	H.221	H.221	H.221	H.22Z	H.223
Signalling	H.245	H.230, H.242	H.230, H.242	H.230, H.242	H.230, H.245	H.245
Multipoint		H.243	H.243	H.243		
Encryption		(in draft revision) H.233, H.234	H.233, H.234	(By reference to H.320)	TBD	H.233 (adapted in H.324), H.234

Table B.3 Synoposis of ITU-T Standards

Number	Title/Description	Status
Architectural		

Number	Title/Description	Status
T.120	*Transmission Protocols for Multimedia Data* . ==> application sharing. The T-120 series governs the audiographic portion of the H.320 series and operates either within H.320 or by itself (Reference [IMTC]). Now that T.120 has come along, "old -style" H.320 multipoint control units (MCU's) will certainly move towards supporting the added component of T.120 carried in the multi-layer protocol (MLP) channel. But there is also now the possibility of non -H.320 conferencing that supports subsets of the audio + video + data combinations. In summary, T.120 • provides a Multipoint data communications service that has application in all forms of multimedia communication. standards (to include whiteboard, file transfer, etc.) • provides Real time speech and video. • runs on PSTN, ISDN, CSDN, PSDN, B-ISDNs, LANs. • encapsulates the concepts involved in all the following protocols. ITU-T T.120, A summary of what the T.120 series of recommendations encompass can be found in reference [S.12]. For completeness this summary has been excerpted from refernce [S.12] and is presented below (i.e., T121-T.128). Some additional annotation of the reference data was made to update the latest understood status of the standard. This data was obtained from reference [S.13].	Core sections are adopted
T.121	*Generic Application Template* , ==> • defines a template to which specific application functionality can be added. • guide to application protocol developers ensuring a consistent approach to the development of application protocols.	Resolution Approved Feb-96
T.123	*Protocol Stacks for Audiographic Teleconferencing* **==>** • presents a uniform OSI Transport interface and services to the MCS layer above. • Basically a profile of the ISDN, CSDN, PSDN, PSTN networks in comparison to the OSI 7 layer network architecture. A preliminary LAN profile is also mentioned.	Draft Feb-96
T.124	*Generic Conference Control* ==> • provides functions such as conference establishment and termination, managing • roster of participating term inals, managing roster of applications application • capabilities within a conference, coordination of conference conductorship.	Resolution 1 approved Mar-96

Number	Title/Description	Status
T-126	*Multipoint Still Image and Annotation Protocol* ==> • provides a protocol to support shared "whiteboard" and exchange of still images with annotations. • application control using keystrokes and mouse. • fax functionality.	Resolution 1 approved Mar-96
T.127	*Multipoint Binary File Transfer* ==> • a protocol to support intercha nge of binary files within a conference. • allows broadcast of multiple files simultaneously. • private distribution of files to a selected subgroup. • conductor control of file distribution.	Resolution 1 approved Mar-96
T.128	*Audio Visual Control for Multipoint Multimedia Systems* ==> • a control application that sets out procedures for the management of real-time audio and video channels in a conference. • transmits control signals directly using a top priority static channel where necessary.	Draft, Jan-96
ITU-T H.320	an ITU "umbrella" standard for "Narrow -band visual telephone systems and terminal equipment." The existing H.320 umbrella covers several different types of standards that govern video, audio, control, and system components. Under H.320 there are at least four other standards and three audio standards as briefly discussed below.	Adopted
H.321	*Visual Telephone Terminals over ATM* "	Work-in-progress
H.322	*Visual Telephone Terminals over Guaranteed Quality of Service LANs*	Work-in-progress
H.323	*Visual Telephone Terminals over Non -Guaranteed Quality of Service LANs* , ==> an impending ITU-T standard that defines videoconferencing over packet switched local area networks such as Ethernet.	Work-in-progress
H.324	H.324 , "*Visual Telephone Terminals over GSTN* ==> This is a recommendation for real -time voice, data, and video over V.34 modems on the GSTN (POTS) telephone network. It is also referred to as PictureTel H.324 Archive. H.324 includes the functional standards as shown in Table B.2.	Approved (Nov-95)
	Video Compression	
H.120	*Codecs for Videoconferencing Using Primary Digital Group Transmission*	Adopted

Number	Title/Description	Status
H.261 H.261 (Cont)	*Video Codec for Audiovisual Services at px64 Kbps* . ==> Describes how video information can be compressed and transported via a number (P) of 64 kbps (or 56 Kbps) channels. The compressed video comes in two standards, Common Interface Format (CIF) and Quarter CIF (QCIF), which are resolutions of the video window. CIF describes a window that is 352x288 pixels, and QCIF describes a 176x144 pixel window. [G.12] The standard requires H.261 devices to encode only the difference between a frame and the previous frame. [V.7] Note, for an H.261 subsystem to meet the peak range of the standard--30 fps with full motion estimation and loop filtering -- it must execute approximately 8 billion operations per second. [V.7] (A common misconception, exploited by some equipment manufacturers, is that compliance with H.261 is enough to guarantee interoperability).	Adopted
H.262, ISO/IEC 13818-2 (MPEG-2 Video)	*Information Technology -- Generic Coding of Moving Pictures and Associated Audio Information --Part 2: Video*	Draft (DIS)
H.263	*Video Coding For Low Bitrate Communication* " ==> is backward-compatiable with H.261, offers improved picture quality by using a half-pixel new-motion estimation scheme rather than H.261's integer-estimation approach. [V.7]	Approved
	Audio	
G.711	*Pulse Code Modulation (PCM) of Voice Frequencies* ==> Describes audio transport at 64 Kbps and 3 kHz. (Algorithm = mu-law in US and Japan, Algorithm = A-law in Europe [G.1]	Adopted
G.722	*7 KHz Audio -Coding Within 64 kbit/s* ==> describes audio transport at 48 Kbps at 7 Hz (almost CD quality). Algorithm = ADPCM [G.1]	Adopted
G.723	*Dual Rate Speech Coder for Multimedia Telecommunications Transmitting at 6.4 and 5.3 kbit/s* "	Adopted Mar-96
G.728	*Coding of speech at 16 Kbps Using Low-Delay Code Excited Linear Predictionat 3 Khz using low -delay code excited linear prediction* ==> describes audio transport at 16kbps at 3khz. Algorithm = ADPCM [G.1]	Adopted
ISO/IEC 11172-3 (MPEG-1)	*Information Technology- Coding of Moving Pictures and Associated Audio Information for Digital Storage Media at up to about 1.5 Mbits/s - Part3:Audio*	Adopted
H.222, ISO/IEC 13818-3 (MPEG-2)	*Information Technology- Generic Coding of Moving Pictures and Associated Audio Information - Part3:Audio*	Adopted
	Data	
T.120	*Transmission Protocols for Multimedia Data* . ==> application sharing. The T-120 series governs the audiographic portion of the H.320 series and operates either within H.320 or by itself [S.3] Defines point-to-point and multipoint document conferencing standards (to include whiteboard, file transfer, etc.) over a variety of transmission media. Now that T.120 has come along, "old -style" H.320 multipoint control units (MCU's) will certainly move towards supporting the added component of T.120 carried in the multi-layer protocol (MLP) channel. But there is also now the possibility of non -H.320 conferencing that supports subsets of the audio + video + data combinations.	Core sections are adopted
T.434		

Number	Title/Description	Status
T.84		
Multiplex		
H.221	"*Frame Structure for a 64 to 1920 kbit/s Channel in Audiovisual Teleservices* ." ==>channel aggregation (H.221 channel aggregation can handle up to 6 B channels, but most connections in North America, over 2B, use BOnDInG (Bandwidth on Demand Interoperability Group). In most cases, at least two B connections are required for decent quality. Almost all Videoconferencing connections use at least 2B.)	Adopted
BOnDInG	*Bandwidth On Demand Interoperability Group* ==> inverse -multiplexing box standard which aggregates channels for video conferencing. (If an H.320 standards -based codec is used, the H.221 channel aggregation standard built in to H.320 is applicable.)	Adopted
H.223	*Multiplexing Protocols for Low Bitrate Multimedia Terminals* "	Work-in-progress
Signalling		
H.230	*Frame-Synchronous Control and Indication Signals for Audiovisual Systems* , ==>describes communications, control, and indication.	Adopted, Balloting for revision
H.242	*System for Establishing Communication Between Audiovisual Terminals Using Digital Channels Up to 2 Mbit/s* ==>describes communications, control, and indication.	Adopted
H.245	*Control of Communications Between Multimedia Terminals*	Draft
Multipoint		
T.125	*Multipoint Communication Service Protocol Specification* • specifies the format of protocol messages and procedures for implementing MCS defined by T.122	Adopted
T.122	*Multipoint Communication Service for Audiographics Conferencing* • Generic connection-oriented data service that collects point to point transport • connections and combines them to form a Multipoint Domain. • provides broadcast, with flow control. • provides multipoint addressing (one to (all, sub-group, one)). • ensures shortest path to each receiver and uniform sequencing of data. • resource contention (availability of channels) is resolved using tokens. • assumes error free transport connections with flow c ontrol.	Adopted
H.232	*Broardband Multipoint Control*	Future
H.243	*System For Establishing Communication Between Three or More Audiovisual Terminals Using Digital Channels Up To 2 Mbit/s* . ==>Defines the MCU protocol standard. Provides conference control functions like chair control / directorship, selecting a particular terminal to be the broadcast video, muting video and audio from particular terminals as desired, etc..	Adopted
Encryption		

Number	Title/Description	Status
H.233	Confidentiality System for Audiovisual Services	Adopted
H.234	Encryption Key Management System for Audiovisual Services	Adopted

Appendix C

Industry Profile for Video Teleconferencing

Industry Profile for Video Teleconferencing

DEFENSE INFORMATION SYSTEMS AGENCY
JOINT INTEROPERABILITY AND ENGINEERING ORGANIZATION
FORT MONMOUTH, NEW JERSEY 07703-5613

IN REPLY 30
MAY 1995
REFER TO: Information Transfer Standards Department
JEBBC

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Industry Profile for Video Teleconferencing (VTC)

1. We are pleased to present you with a copy of the latest version of the Industry Profile for Video Teleconferencing, document # VTC001-Rev. 1. It was approved by an industry/government working group on April 25, 1995 in order to improve interoperability and standardization of VTC. The document was formerly known as the COS (Corporation for Open Systems) VTC Profile.

2. The Industry profile was recently enhanced to include multipoint (Multipoint is the capability for three or more sites to conduct a simultaneous conference). It applies to desktop VTC, rollabout units, dedicated facilities, and multipoint control units. The international standards cited in the Profile are fully interoperable with the federal standard for VTC, FIPS PUB 178.

3. ASD-C3I policy dated 31 Oct 1994 states that the Industry profile for VTC is the official DOD standards document for VTC procurement. According to the policy, "Effective immediately, all new procurements for VTC that operate between transmission data rates of 56 to 1920 kb/s should conform to the requirements of the COS VTC profile." This means that new procurements for VTC operating in these data rates should cite the latest version of the Industry Profile in the procurement contract, and require compliance with it.

4. Additional paper copies of the profile can be obtained from the Corporation for Open Systems International, 8260 Willow Oaks Corporate Drive, Suite 700, Fairfax, VA 22031. the COS point of contact is Mr. David Kelley (703)205-2762.

5. **Electronic copies of the profile can be obtained via the internet in two ways. Using the World Wide Web, the URL address is "HTTP://WWW.ITSI.DISA.MIL/". Click on "STANDARDS DOCUMENT LIBRARY", then "BY STANDARDS ORGANIZATION", then "COS". Another way is using file transfer protocol (FTP). The address is "FTP.COS.COM". (Username: "ANONYMOUS"; password: "ANONYMOUS" or your user name; file directory: "DOC"; subdirectories: "VIDEO" and "VIDEOPRO").**

6. For your information, COS has completed point-to-point interoperability testing of six different commercially available VTC systems, including three desktop units. All units attained a basic level of interoperability, but results varied as to the degree of interoperability and degree of compliance with the industry profile. A summary of the interoperability test results are in the COS VTC Systems Interoperabilty Register, document # VTCSIR-001, which can be obtained as per para. 4. The profile was used as the foundation upon which the interoperability tests have been developed. The interoperability register will be periodically updated as new equipment is received by COS. Cooperative testing efforts between COS and DOD organizations are encouraged. DISA POC is Mr. Klaus Rittenbach, DSN 992-7715 or COMM (908)532-7715; E-mail is Rittenbk@CC.IMS.DISA.MIL.

---- signed ----
LOUIS J PILLA
Chief, Information Transfer Standards Department

#2882, COS (Corporation for Open Systems
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