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ANALYSIS OF STANDARDS AND PRODUCTS FOR DESKTOP TELECONFERENCING

Richard P. Morton, *Task Leader*

November 1995

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Joint Interoperability and Engineering Organization
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PREFACE

This document was prepared by the Institute for Defense Analyses under the Task Order, Multimedia Technology Standards and Their Use in DoD Applications with Emphasis on GCCS. The work was sponsored by the Center for Standards of the Joint Interoperability and Engineering Organization (JIEO) of the Defense Information Systems Agency (DISA), and relates to an objective of the task "to assist the Center for Standards in developing suitable guidance for the adoption and use of multimedia standards for the wide range of DoD applications of multimedia technology."

This document was reviewed by the following IDA staff members: Dr. Edward Feustel, Dr. Michael Frame, Dr. Michael Kappel, Dr. Dale Lichtblau, and Dr. Reginald Meeson. Their contributions are gratefully acknowledged.

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EXECUTIVE SUMMARY

Purpose

This document explores many aspects of teleconferencing standards and products for the purpose of providing guidance on the acquisition of teleconferencing capabilities. The objective is to provide a level of understanding about the state of standards development in support of teleconferencing and the level of support in the industry for standards to support program managers and others contemplating the acquisition of teleconferencing systems.

Background

This document was prepared as a result of a request from the Global Command and Control System (GCCS) Engineering Office to the Center for Standards for information on standards and products that would be useful in support of distributed collaborative planning (DCP). It is recognized that teleconferencing technology by itself is not a total solution to DCP needs, but it is a useful tool that is being employed in limited situations today. At present, GCCS provides some teleconferencing capabilities, but lacks particular desired features such as video teleconferencing.

Teleconferencing is one mechanism for supporting interactions among two or more people, specifically where the participants are interacting at the same time but not all in the same place. There may be two or more locations participating in a single teleconference. There may be one or more people participating in the teleconference at each site. The interaction may be facilitated by the interchange of audio, video, or computer data. When computer data is used, the participants may be able to change it or only allowed to annotate it.

Scope

Not all teleconferencing product areas are included. The focus in this analysis is desktop teleconferencing, including desktop video teleconferencing, since it is desktop capabilities that could reasonably become part of GCCS. Desktop teleconferencing is real time communications among people at two or more locations, involving two or more media

(audio, video, or computer data including imagery), and at least one participant in the teleconference using a desktop system.

Approach

The information contained in this document was obtained by talking with standards developers and vendor representatives, attending trade shows, reading standards documents and product literature, and reading the World Wide Web (WWW) pages of standards organizations, related university research projects, and vendors of teleconferencing products.

Findings

The findings in this analysis demonstrate the importance of standards to teleconferencing systems and where in those systems standards matter; show the activities of the teleconferencing standards community, identifying the organizations involved, the areas of their activity, the nature of existing and emerging standards, and the status of those standards; provide a broad overview of a large number of teleconferencing products, with particular focus on the standards they employ; and address issues of specific concern to DoD related to standards and products for teleconferencing. The findings of specific concern to DoD are:

- There is an officially approved DoD profile for video teleconferencing systems[1] which is adequately supported by commercial products.
- The approved profile does not meet all DoD requirements for teleconferencing.
- There are numerous products that provide capabilities not yet standardized, but no de facto standards that have gained widespread market acceptance.

Conclusions

The conclusions presented in this document are:

- Vendors will invest in standards-based technology only when they see a stable standards environment.
- The approved DoD profile satisfies the need for video teleconferencing without data over communication links in the bandwidth range in which it applies.

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[1] *COS Video Teleconferencing Profile*, Corporation for Open Systems International, April 1995.

- The approved profile does not meet all DoD requirements for teleconferencing at this time.
- In the critical area of teleconferencing from workstations on LANs, it is likely to be several years before a market dominating technology is identified.

Recommendations

This document makes the following recommendations:

- Adhere to the adopted DoD profile for video teleconferencing where the bandwidth can support it.
- Even where profile requirements can be met, wherever feasible, acquisitions should be delayed until the standards associated with Recommendation T.120 of the International Telecommunications Union are incorporated into products and the DoD profile.
- Proprietary solutions should be considered only where the benefits outweigh the cost of later replacing them by standardized systems, which in some cases may be available as soon as one or two years from now.
- Avoid major investments in teleconferencing products that do not support clear market-leading standards.

1. INTRODUCTION

1.1 PURPOSE AND SCOPE

This document was prepared as a result of a request from the Global Command and Control System (GCCS) Engineering Office to the Center for Standards for information on standards and products that would be useful in support of distributed collaborative planning (DCP). It is recognized that teleconferencing technology by itself is not a total solution to DCP needs, but it is a useful tool that is being employed in limited situations today. (Other potentially useful technologies include computer-supported cooperative work (CSCW) tools and workflow systems. Future efforts may address these areas.) At present, GCCS provides some teleconferencing capabilities, but lacks particular desired features such as video teleconferencing.

This document explores many aspects of teleconferencing standards and products for the purpose of providing guidance on the acquisition of teleconferencing capabilities. The objective is to provide a level of understanding about the state of standards development in support of teleconferencing and the level of support in the industry for standards to support program managers and others contemplating the acquisition of teleconferencing systems. Not all teleconferencing product areas are included. The focus in this analysis is desktop teleconferencing, including desktop video teleconferencing, since it is desktop capabilities that could reasonably become part of GCCS. Two specific areas that are frequently included within the domain of teleconferencing but are not addressed in this document are audio conferencing and distance learning.

1.2 APPROACH

The information contained in this document was obtained through the following activities:

- Discussions with standards developers and vendors
- Studying standards documents
- Reviewing product literature

- Obtaining other information from a variety of sources, particularly the Internet.

The availability of information about teleconferencing standards and products has improved dramatically in recent years with the growth of trade shows and on-line information devoted to the subject. There are now several major trade shows each year that have teleconferencing vendor participation. For this study, the 1995 International Teleconferencing Association show, ITCA 95, was attended. Previous shows attended included Desktop Video Conferencing (DVC), and Comdex. These events provided the opportunity to observe product demonstrations, talk with vendors about current and future plans for standards conformance, and get general impressions about the direction of the industry. Additional information about products was obtained from the Internet, particularly the newsgroup comp.dcom.videoconf and the world wide web (WWW) site of the Succeed Project at the University of North Carolina (http://www2.ncsu.edu/eos/service/ece/project/succeed_info/dtvc_survey).

Most of the information about the status of standards was obtained from the Internet, particularly from the WWW server of the International Telecommunications Union (ITU) at http://www.itu.ch, and the WWW server of the Internet Engineering Task Force (IETF) at http://www.ietf.cnri.reston.va.us. Additional information was obtained through contacts within the Center for Standards.

1.3 DOCUMENT ORGANIZATION

Section 2 of this document provides background information on the nature of teleconferencing and the supporting technology. Section 3 presents the findings of this study which provide the basis for the conclusions presented in Section 4 and the recommendations in Section 5. Appendix A provides information for a sizable number of teleconferencing products.

2. BACKGROUND

2.1 INTERACTIONS AMONG PEOPLE

Teleconferencing is one mechanism for supporting interactions among two or more people. What distinguishes teleconferencing from the other interactions support mechanisms is that the participants are interacting at the same time but not all in the same place. Consider Table 1.

Table 1. Interaction Domains and Tools

	Same Time	Different Time
Same Place	Brainstorming facilitation systems Blackboards Overhead Projectors	Sticky notes Bulletin Boards
Different Place	Teleconferencing	Electronic mail Groupware

Interaction among people can take place in any of the four time/place quadrants indicated, and there are different tools to assist interactions in each case. Some of the tools to support interactions in the same time/same place are systems that provide the capability to facilitate the generation of ideas. These systems permit all participants in a room to enter ideas and comment on them without attribution. Other, less high tech, tools in this quadrant include blackboards and overhead projectors.

The simplest tools for supporting interactions in the same place/different time quadrant are sticky notes and bulletin boards, and today there are electronic versions of both.

Computer-based tools for supporting interactions in the different time/different place quadrant include e-mail and groupware tools. These tools generally allow people working independently to produce output that others can review, comment on, or enhance at a later time.

2.2 TYPES OF TELECONFERENCING

Teleconferencing tools provide the capability for people who are not all at the same place to interact in real time. The number of sites participating in a single teleconference can range from two to several, and the number of participants at each site can range from one to many. The interaction can be free-wheeling, with all participants considered equal, or it can be primarily one-way, with limited interaction in the other direction, for example, as in a remote classroom. The interaction can be strictly through voice conversations, through a combination of voice and video, through keyboards and pointing devices, or all of these. For audio only, the telephone, particularly the speakerphone, is a teleconferencing tool. The capabilities of the telephone range from one person per site (simple telephone calls), to a few people per site (using a single speaker and microphone), to many people per site in a meeting room equipped with elaborate speakers and many microphones.

Video teleconferencing (VTC) includes all the same scaling options. Desktop VTC is intended to support one person per site. Small, roll-about systems are intended for small groups, and large, permanent installations are intended to support many people at a single site. *Multipoint* VTC includes three or more sites. Group coordination can be supported by split screen capabilities that display multiple sites and participants at the same time, provided that sufficient communications bandwidth is available to accommodate all the signals at the same time. VTC may also include the ability to share computer data, including imagery, in any of several different ways. The simplest form of data sharing is to simply point a camera at a document. When a computer is part of the system, such as is the case with desktop VTC, documents can also be displayed in a "shared whiteboard" window where each of the participants can mark up the document but cannot change it. With the capability for "shared applications" some or all the participants in the teleconference can actually change the document by sharing access to the application that is used to make the changes.

Audiographic teleconferencing is the capability for participants to share data and talk about it as in a VTC, but without the ability to see each other. Either shared whiteboard or shared application capability is the mechanism for data sharing, since video is not available. The audio may be carried over the same communications channel as the data or it may be carried over a different channel.

Document teleconferencing is similar to audiographic teleconferencing, but without the audio. The keyboard and pointing device are the only means of communications among the participants.

The type of teleconferencing of interest in this analysis, desktop teleconferencing, is real time communications among people at two or more locations, involving two or more media, and at least one participant in the teleconference using a desktop system. Two or more media means that video teleconferencing, with or without data, and audiographic teleconferencing are of interest. At least one participant using a desktop system means interoperability with room or roll-about systems is also of interest.

3. FINDINGS AND OBSERVATIONS

As noted earlier, the primary objective of this analysis is to provide an understanding of the state of standards and products as guidance in the acquisition of teleconferencing capabilities. This section contains the basic facts necessary to achieve that understanding. It is recognized that some of the items in this section are observations rather than findings in the usual sense of discoveries, but a consistent label of "finding" has been used for simplicity.

3.1 ROLE OF TELECONFERENCING STANDARDS

This section shows the importance of standards to teleconferencing systems and where in those systems standards matter.

Finding 1: Teleconferencing systems must interoperate across communications links, requiring standards to support that interoperation.

Teleconferencing was defined earlier to involve interactions at the same time but in different places. Because the participants are in different locations, they use different systems, and those systems must interoperate if the interactions are to take place. Standards are necessary to ensure that the different systems of the different participants speak the same language. Note: this finding does not imply that there is a requirement that the standards that support this interoperation must be open standards, only that the systems used in an interaction must meet some standards in common.

Finding 2: The communications links must support the types of media used in the teleconference.

The communications links used in support of teleconferencing are particularly important if the teleconference uses audio or video. Audio and video as used in a teleconference are data streams, rather than data files. That is, they go on continuously for the duration of the conference, and the timing of the delivery of the data to the end user, in both delay and synchronization, is critical to the user's ability to understand what is being conveyed in the conference.

Finding 3: Standards for data communication formats are required to provide the necessary interoperability among teleconferencing tools.

Each of the three main areas, video, audio, and computer data, are addressed by different standards. In addition, there are other standards that manage the overall conference and the coordination of video and audio. For both audio and video, there are many standards available, generally as a function of the bandwidth of the available communications links.

3.2 SOURCES, TYPES, AND STATUS OF TELECONFERENCING STANDARDS

This section addresses the activities of the teleconferencing standards community, identifying the organizations involved, the areas of their activity, the nature of existing and emerging standards, and the status of those standards.

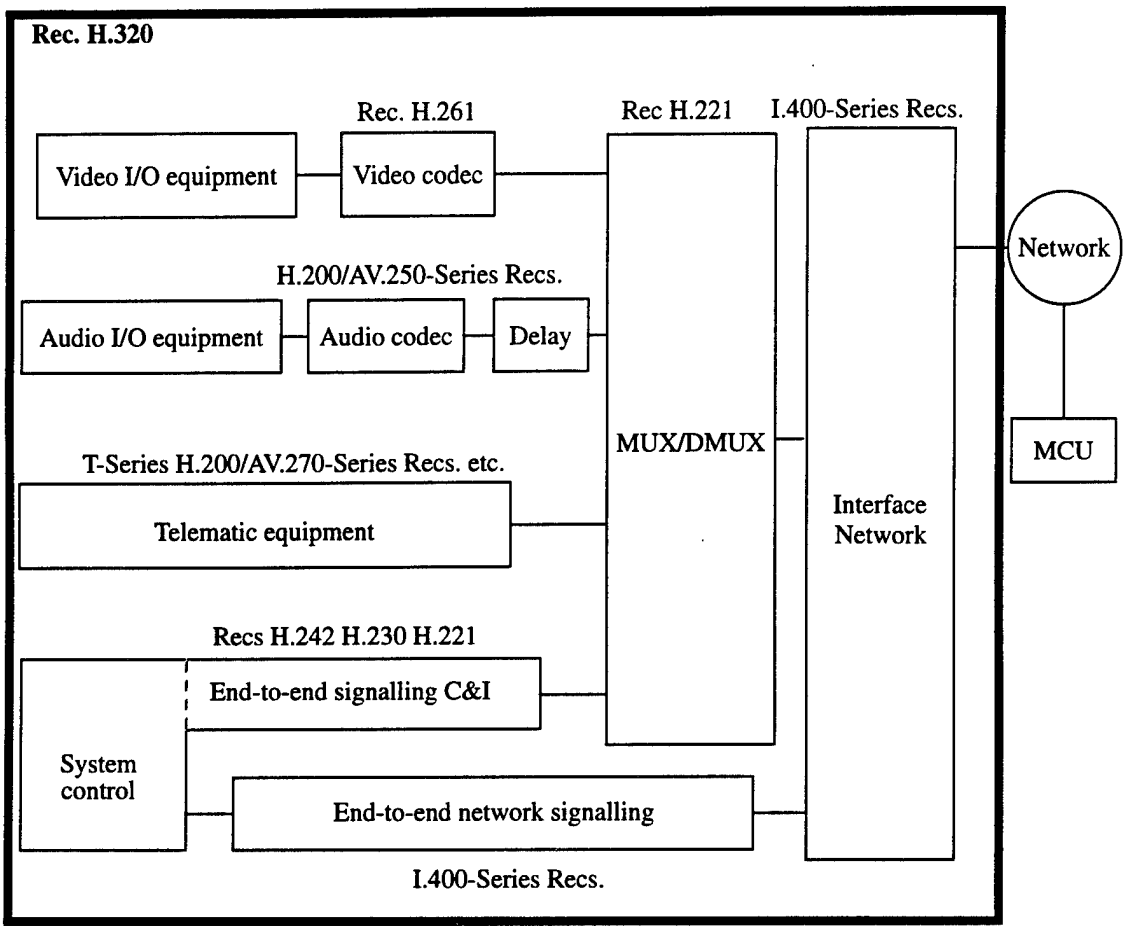
Finding 4: The International Telecommunications Union (ITU) is a major source of teleconferencing standards.

Many of the existing and emerging standards that are required to support interoperability among teleconferencing systems have been developed under the auspices of the International Telecommunications Union (ITU). Additional organizations that are contributing include the International Organization for Standardization (ISO), the Institute of Electrical and Electronics Engineers (IEEE), the Internet Engineering Task Force (IETF), the International Multimedia Teleconferencing Consortium (IMTC), the Asynchronous Transfer Mode (ATM) Forum, and others.

Finding 5: Teleconferencing standards can be divided into architecture and basic function standards.

Architecture standards describe how the basic functions interrelate to form a teleconferencing system. As an example, the architecture standard ITU [International Telecommunications Union] Recommendation H.320, illustrated in Figure 1,[1] prescribes the components of a VTC system that operates over Integrated Services Digital Network (ISDN) communications links and which standards are to apply to each component. The figure shows the functional components of a VTC system and identifies the basic function standards that apply to each component. The references are all to other ITU recommenda-

[1] *Narrow-Band Visual Telephone Systems and Terminal Equipment*, ITU-T H.320, International Telecommunications Union, Geneva, March 1993.



MCU: Multipoint Control Unit

Figure 1. The Structure of H.320

tions. For example, the I.400 Series is the set of standards that describe ISDN. The others are listed in Table 3 following Finding 9. One standard, ITU Recommendation T.120, is both an architecture and a function standard. T.120 is an architecture standard for audio-graphic teleconferencing, and also serves as the data component standard for VTC architectures that incorporate data. The architecture of T.120 is shown in Figure 2. The figure shows the separation of the Application Protocol Recommendations from the Infrastructure Recommendations. The Application Protocol Recommendations are standards for the interchange of specific data types, and serve as the basic function standards when T.120 is part of H.320 or other architecture standard for VTC. The Infrastructure Recommendations are designed to be compatible with the VTC architecture standards, but can stand alone when video is not needed.

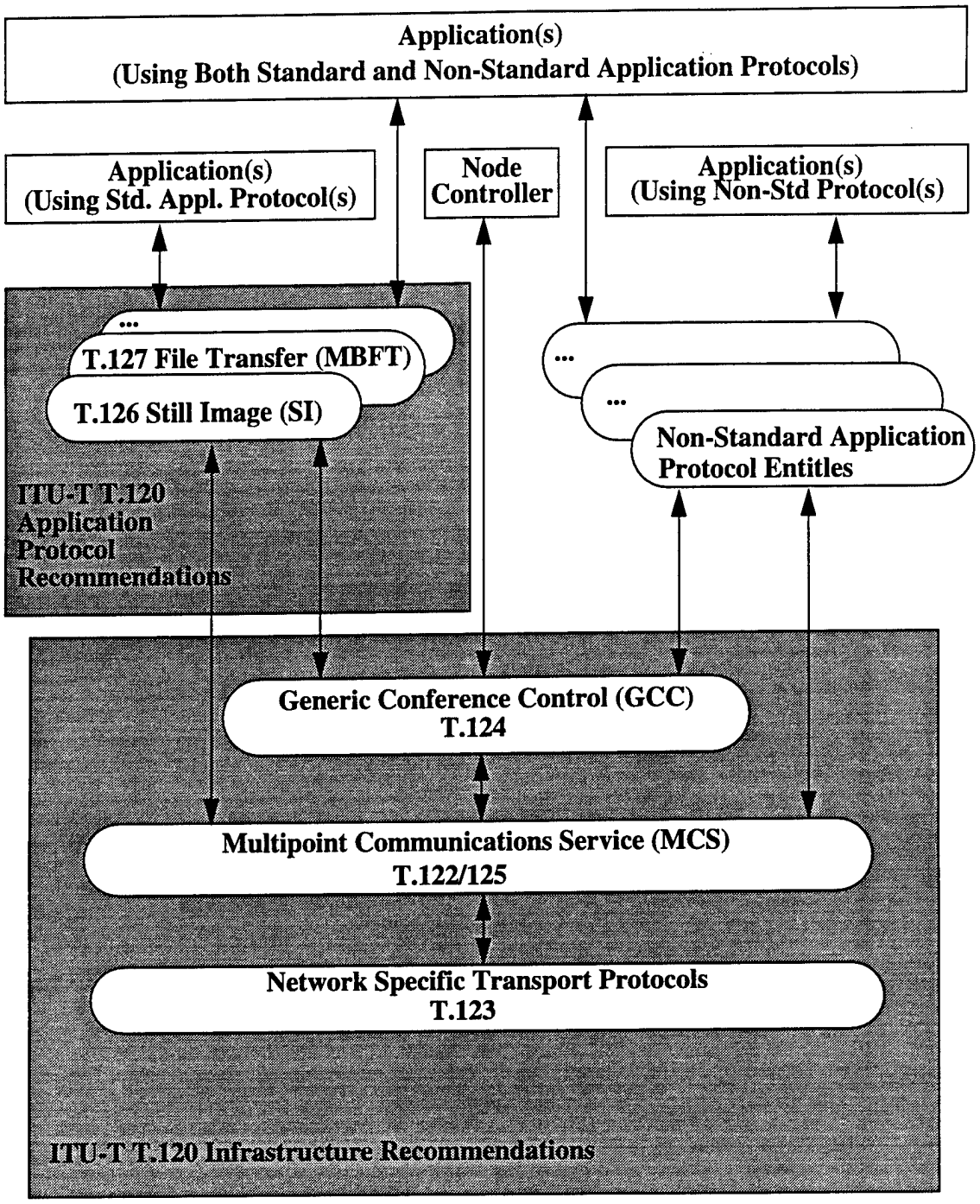


Figure 2. The Architecture of T.120

Finding 6: The teleconferencing architecture standards are each associated with a particular type of communication link.

The teleconferencing architecture standards are listed in Table 2. H.320 is intended

Table 2. Teleconferencing Architectural Standards

Number	Title	Status
H.320	Narrow-Band Visual Telephone Systems and Terminal Equipment	Adopted
H.321	Adaptation of H.320 Visual Telephone Terminals to B-ISDN Environments	Draft
H.322	Visual Telephone Systems and Terminal Equipment for Local Area Networks which Provide a Guaranteed Quality of Service	Draft
H.32Z.2 (H.323)	Visual Telephone Systems and Terminal Equipment for Local Area Networks which Provide a Non-Guaranteed Quality of Service	Draft
H.324	Terminal for Low Bitrate Multimedia Communications	Draft
H.310	Broadband Audiovisual Communication Systems and Terminals	Draft
T.120	Transmission Protocols for Multimedia Data	Balloting

for use on ISDN links; H.321 and H.310 are oriented toward Asynchronous Transfer Mode (ATM) links; H.322 and H.323 relate to local area networks; and H.324 applies to analog modems on ordinary telephone lines.

Finding 7: The first standards to emerge from the ITU are those that rely on the services of the public switched telephone network.

The ITU is the international standards body of the telephone industry, where most of the members are the government Post, Telephone, and Telegraph (PTT) organizations. As a result, their standards generally assume that the underlying communications system for carrying a teleconference is the system of a telephone service provider, either analog switched circuits or one of the newer digital systems such as Integrated Services Digital Network (ISDN). As noted in Table 2, H.320 was the first architecture adopted. H.324 is expected to be the next VTC architecture standard approved. The ITU model for desktop teleconferencing is for each computer involved to have its own connection to the telephone system, and for the telephone service provider to provide the capability for multipoint con-

nections. There are working groups in the ITU considering teleconferencing standards for local area networks (LAN), but the standards are still at least two years away. The current architecture defined by T.120, in particular by T.123, does not include TCP/IP or any other LAN protocol, but it makes reference to the expectation that such will be forthcoming. The accepted protocols in the current version of T.123 are ISDN, X.25, Public Switched Telephone Network (PSTN) using V-series modems, and other switched or permanent digital circuits. ISO and the ATM Forum are participating in the standards for high bandwidth teleconferencing over ATM networks.

Finding 8: The IETF is also exploring network-based teleconferencing services, but their efforts are still experimental.

There are currently no standards adopted by the IETF related to teleconferencing, but there are some efforts underway in this area, primarily within the Transport Working Group. The activities in the transport area are directed initially at the bandwidth and stream data problem; teleconferencing issues specifically will be addressed later as an application of the solutions to the bandwidth and stream data problems. Furthermore, the IETF working groups are coordinating with the ITU with the intention of attaining interoperability with the ITU standards wherever feasible. The relevant subgroups of the transport area are:

- Audio/Video Transport
- Integrated Services
- Multiparty Multimedia Session Control (mmusic)
- Resource Reservation Setup Protocol

Finding 8a: The Audio/Video Transport Working Group was formed to specify experimental protocols for real-time transmission of audio and video over UDP and IP multicast. [2]

No standards have been published by this group, but they have released the following Internet-Drafts (Internet-Drafts are valid for a period not to exceed six months, and are only considered to be works in progress):

- RTP: A Transport Protocol for Real-Time Applications
- RTP Profile for Audio and Video Conferences with Minimal Control

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[2] Findings 8a-8d are taken from the descriptions of the working groups accessed through the IETF Home Page at http://www.ietf.cnri.reston.va.us.

- RTP Payload Format for H.261 Video Streams
- RTP Payload Format of CellB Video Encoding
- RTP Encapsulation of JPEG-Compressed Video
- RTP Payload Format for MPEG1/MPEG2 Video

Finding 8b: The purpose of the Integrated Services Working Group is to specify an enhanced service model for the Internet capable of supporting the transport of audio, video, real-time, and classical data traffic within a single network, and then to define and standardize certain interfaces and requirements necessary to implement the new service model.

The Internet-Drafts of this working group are:

- Network Element Service Specification Template
- Specification of Controlled Delay Quality of Service
- Specification of Predictive Quality of Service
- Specification of Guaranteed Quality of Service

Finding 8c: The Multiparty Multimedia Session Control Working Group is chartered to design and specify a protocol to manage and coordinate multiple sessions and their multiple users in multiple media.

The Internet-Drafts produced by this Working Group are:

- SDP: Session Description Protocol
- Managing Shared Ephemeral Teleconferencing State: Policy and Mechanism

Finding 8d: The primary purpose of the Resource Reservation Setup Protocol (RSVP) Working Group is to evolve the RSVP specification and introduce it into the Internet standards track. RSVP is a resource reservation setup protocol designed for an integrated services Internet.

The Internet-Drafts produced by this Group are:

- Resource Reservation Protocol (RSVP) -- Version 1 Functional Specification
- RSVP Cryptographic Authentication
- Routing Support for RSVP

Finding 8e: Outside the Transport Area, other working groups of the IETF are also involved in supporting the migration of the Internet to an integrated services network.

In the Internet Area, the Stream Protocol Working group has produced the Internet Stream Protocol Version 2 (ST2) Protocol Specification - Version ST2+. Although ST2+ is currently making the jump from Internet-Draft to Request for Comment (RFC), it is only an experimental protocol. This means it is not a standard, but it is stable and has been implemented in a few commercial products. If ST2+, or a successor, achieves widespread penetration of the Internet, it could serve as the basis for extending the applicability of the H.320 series, most likely H.322, to wide area networks based on Internet technology rather than telephone technology.

Finding 8f: Some experimental teleconferencing has been conducted on the Internet.

The most widely known and used is the Multicast Backbone (Mbone). The Mbone service has been implemented on top of experimental implementations of the above listed Internet-Drafts, and some of that experience has led to revisions and further experiments. It appears, however, that it will be some time before enough standards-track RFCs have been adopted by the IETF to provide a complete teleconferencing capability on the Internet. In the meantime, the experimental protocols can be used, and in some cases, may prove to be as stable as adopted standards. The vendor community, however, does not appear to be ready to commit on a wide scale basis.

Finding 9: There are multiple varieties of standards for each of the functional components of the teleconferencing architectures.

The set of choices for each of the functional components for each ITU architecture are shown in Table 3. The names of these standards are provided in Tables 4-6.

3.3 DESKTOP TELECONFERENCING PRODUCTS

This section provides a broad overview of a large number of teleconferencing products, with particular focus on the standards they employ.

Finding 10: There is a wide range of commercially available video and audiographic teleconferencing products available for use with computers.

See the table in Appendix A for a list of products and their characteristics.

Table 3. Relationships Among Architectural and Functional Standards[a]

	H.320	H.321	H.322	H.32Z.2	H.324	H.310
Video	H.261	H.261	H.261	H.261, H.263	H.263	H.261, H.262 (MPEG-2)
Audio	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	G.7xx, MPEG-1, MPEG-2
Data	T.120	T.120	T.120	T.120	T.120, T.434, T.84, Others	T.120
Multiplex	H.221	H.221	H.221	H.22Z	H.223	H.222.1, H.221
Signalling	H.230, H.242	H.230, H.242	H.230, H.242	H.230, H.245	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	

a. This table is adapted from a similar table in a briefing by Gary A. Thom, Delta Information Systems. The standards listed in this table are identified in Tables 4 through 6.

Table 4. ITU Recommendations Related to Video Compression

Number	Title	Status
H.120	Codecs for Videoconferencing using Primary Digital Group Transmission	Adopted
H.261	Video Codec for Audiovisual Services at p x 64 kbits/s	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 Communications	Draft

Table 5. ITU Recommendations Related to Audio Encoding

Number	Title	Status
G.711	Pulse Code Modulation (PCM) of Voice Frequencies	Adopted
G.722	7kHz Audio-coding Within 64kbits/s	Adopted
G.723	Dual rate speech coder for multimedia communications transmitting at 5.3 & 6.3 kbits/s	Draft
G.728	Coding of speech at 16 kbits/s using low-delay code excited linear prediction	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 -- Part 3: Audio	Adopted
ISO/IEC 13818-3 (MPEG-2)	Information Technology -- Generic coding of moving pictures and associated audio information -- Part 3: Audio	Adopted

Finding 11: Many teleconferencing product vendors are supporting the open standards, particularly the H.320 suite.

The vendors recognize that if they are to grow the market beyond where it is today their products will need to interoperate. At present, H.320 is the only standard stable enough to ensure interoperability.

Finding 12: At the present time, most of the desktop teleconferencing product development is aimed at the personal computer market, with ISDN as the primary mode of communication.

Appendix A lists 57 desktop teleconferencing products commercially available. Of these, 42 operate on personal computers (supporting the Intel x86 architecture and one of the Microsoft operating systems, generally Windows), 11 support a variety of Unix systems, and 11 support the Apple Macintosh. (The numbers add up to more than the total because some products operate on more than one type of systems.) ISDN is supported by 36 of the 57 products.

Table 6. ITU Recommendations Related to Conference Control and Security

Number	Title	Status
H.221	Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices	Adopted, Balloting for revision
H.222, ISO/IEC 13818	Information Technology - Generic coding of moving pictures and associated audiovisual information (MPEG-2)	Adopted
H.223	Multiplexing protocol for low bitrate multimedia communications	Draft
H.230	Frame-synchronous control and indication signals for audiovisual systems	Adopted, Balloting for revision
H.232	Broadband multipoint control	Future
H.233	Confidentiality system for audiovisual services	Adopted
H.234	Encryption key management system for audiovisual services	Adopted
H.242	System for establishing communications between audiovisual terminals using digital channels up to 2 Mbits/s	Adopted
H.243	Procedures for establishing communications between three or more audiovisual terminals using digital channels up to 2 Mbits/s	Adopted
H.245	Control of communications between multimedia terminals	Draft

Finding 13: Many of the vendors whose products are based on H.320 are expecting to add T.120 compliance as soon as T.120 is approved.

Approval for T.120 is expected in February 1996. The vendors at ITCA 95 who were exhibiting H.320 compliant products all indicated plans to support T.120. A representative from Intel Corp. indicated that he expected his company to have a T.120 version in the market by March 1996.

Finding 14: There are a few products that operate over local area networks.

See Appendix A for some of these. However, with the exception of those that operate on IsoEthernet, few, if any, of them will interoperate with any other teleconferencing products.

Finding 15: Products that translate from one suite of standards to another have been implemented in hardware to fit into the network at the point of intersection. These points are also where multipoint control is being provided.

For example, network interfaces to ISDN lines provide a number of optional functions, such as video and audio compression conversion, multipoint control, multiplexing multiple teleconferences over the same link, and reverse multiplexing to permit a single teleconference to make use of multiple ISDN links. At ITCA 95 several vendors demonstrated products that provided interfaces between ISDN lines and IsoEthernet LANs.

Finding 16: Proprietary products include a variety of technologies that differ from the adopted standards, particularly in the area of compression.

There are many different compression algorithms available, and each has its proponents and detractors. One potentially important example is based on a technology called wavelets, and is used by Intel Corp. in its Indeo products. Intel has announced that its current suite of products that include Indeo compression will be enhanced to include teleconferencing capabilities. They claim that their products will provide better performance for a given communications bandwidth than what will be achieved by the technology embedded in the standards. They also claim to have the support of IBM in their endeavors to promote Indeo teleconferencing.[3]

Finding 17: There are a number of competing networking technologies that could be used in teleconferencing, but there is no clear market winner at this time.

The primary stumbling block is the issue of how to deal with the streaming and synchronization problems required to meet the demands of video and audio in teleconferences. The only approved standard in this area is the IEEE 802.9a Isochronous Ethernet. The major drawback of this, or of any other standard that might be proposed, is the need to replace a very large installed base of network devices. There are several vendors selling 802.9a compatible hardware, but there does not appear to be a significant trend among buyers to acquire these products. The several experimental Internet protocols that have been tried suffer from a similar problem in that they require changes to the installed base of Internet technology.

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[3] See the Intel home page at http://www.intel.com.

There are fundamental reasons why most of the existing data networks do not readily support audio and video stream data. Packet switched data networks were designed to multiplex all users onto the same links without regard for end-to-end delays. The quality of service guarantees required by audio and video data are that the data will be delivered at the same rate at which it is presented. It is this conflict in priorities, particularly the need to support both simultaneously, which has delayed finding an acceptable solution to the data network teleconferencing problem.

3.4 TELECONFERENCING SYSTEMS FOR DOD

This section addresses issues of specific concern to DoD related to standards and products for teleconferencing.

Finding 18: There is an officially approved DoD profile for video teleconferencing systems[4] which is adequately supported by commercial products.

That profile adopts the H.320 suite of standards. The intent is that the profile will be updated to include additional standards as they are adopted. Interoperability testing is provided by the Corporation for Open Systems (COS). Many vendors have submitted their products for testing, and COS maintains a list of those that have passed.

Finding 19: The approved profile does not meet all DoD requirements for teleconferencing.[5]

DoD requirements for teleconferencing extend beyond the capabilities addressed in the H.320 standard. Both additional functions and a wider range of communications modes are needed. The necessary capabilities are expected to be addressed in H.320 and other standards eventually, but the standards are not in place yet, and, hence, they are not referenced in the DoD profile.

Finding 20: There are numerous products that provide the capabilities not yet standardized, but no de facto standards that have gained widespread market acceptance.

This does not mean that there are products that meet all DoD requirements. In the specific areas of additional communications links and application sharing, there are a variety of commercial products that meet a wide range of needs. However, in those areas where

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[4] *COS Video Teleconferencing Profile*, Corporation for Open Systems International, April 1995.

[5] See, for example, the requirements identified in *Software Requirements Specification for Multimedia System Services, GCCS Common Operating Environment*, September 28, 1995 draft.

there are no approved international standards, there is virtually no interoperability between the products of different vendors.

4. CONCLUSIONS

Conclusion 1: Vendors will invest in standards-based technology only when they see a stable standards environment.

As international standards are approved, commercial products will emerge quickly. Getting into the market quickly is obviously important to the vendors. They already recognize the need for interoperability and the role the standards play in ensuring interoperability. As soon as they believe new standards are stable, they are and will continue to invest in the technology to meet the standards. For example, the vendor community adoption of H.320 and their promises for T.120 are in sharp contrast to their reaction to the teleconferencing efforts in the Internet community, where the market is potentially much larger. The instability of the IETF VTC standardization efforts is discouraging most vendors from committing resources to product development.

Conclusion 2: The approved DoD profile satisfies the need for video teleconferencing without data over communication links in the range in which it applies.

For video teleconferencing over communications links in the range of 56kbps to 1.92Mbps where data sharing is not required, the approved DoD profile is sound. The profile is based on the H.320 standard which is stable and well supported by commercial products. For those applications where it meets the requirements, there is no reason not to employ it. In fact, within this range of requirements, it will be difficult to find many products that do not meet the requirements of the profile because such products would not interoperate with the rest of the world.

Conclusion 3: The approved profile does not meet all DoD requirements for teleconferencing at this time.

Indeed, the range of standards that have been approved by international standards bodies does not meet all DoD requirements. Two major missing parts are standards for a wider range of communications bandwidths and the component of H.320 that defines the standard for data sharing (T.120). T.120 is expected to be approved in February 1996, but

the part of it that addresses application sharing is still several years away. Standards for teleconferencing over additional communications links will be added over the next couple years, with some appearing very soon.

Conclusion 4: In the critical area of teleconferencing from workstations on LANs, it is likely to be several years before a market dominating technology is identified.

There are competing approaches to a solution for LAN-based teleconferencing including multiple international standards and proprietary approaches. The standards that provide the best performance require investments in new hardware. Some of the proprietary solutions claim to provide comparable performance over existing networks, and are being actively marketed now. There are also new developments in LAN technology that could provide higher over-all bandwidths, but are not yet being addressed by any teleconferencing standards efforts or products, and requirements in other areas besides teleconferencing could lead to new investments in some of these. The impact that ATM will have on the LAN market is not clear. The mere existence of an international standard and some vendor products does not guarantee a market success for any standard.

5. RECOMMENDATIONS

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

Where the communications links are between 56kbps and 1.92Mbps, generally Switched-56, dedicated 56, or ISDN, the approved profile is widely supported by COTS products. The Corporation for Open Systems performs interoperability testing, and maintains a list of those products that have been tested. It should be kept in mind, however, that the current version of the profile does not address data sharing, either in the form of shared whiteboards or shared applications.

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

It is expected that ITU Recommendation T.120 will be approved in February 1996, and products will be available shortly thereafter. It is expected that the COS profile, and by reference, the DoD profile, will be updated as soon as practical to reflect T.120. The approval of the standard does not guarantee interoperability, however, so it will be best to delay acquisition decisions until interoperability testing can be confirmed. Ideally, this means waiting for the update to the COS profile. If that is not possible, the next best solution will be to wait until interoperability is demonstrated by the vendors, for example at a trade show. At the very least, potential vendors' commitments to later upgrades to T.120 should be considered in any early acquisitions.

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.

There may be cases where the acquisition of teleconferencing products can be clearly justified but for which the adopted profile does not meet the requirements, for example for LAN-based teleconferencing or for application sharing. In such cases, the acquisition of proprietary technology may be appropriate, but it should be recognized that interopera-

bility will be limited to others with the same brand of products. Moreover, as new standards are approved, the rest of the world will undoubtedly go in a different direction, making today's purchases obsolete. If this can be cost justified, then the acquisition should proceed, with the understanding that the products will be scrapped and replaced when the market direction in standards-conformant products becomes clear, and tight controls should be placed on the spread of the proprietary technology to minimize the inertia to avoid the expense of changing. These expenses can be quite high because of the number of components it takes to complete a teleconferencing connection. It is likely that the cameras and microphones will remain compatible, but the software, network interface cards, routers and switches, multipoint and multiplexing adapters, and software are a few of the components that could potentially need to be replaced. Many of these are replicated at every workstation with teleconferencing capability, so it is important to keep the number of such workstations to a minimum until the industry becomes more stable.

Recommendation 4: Avoid major investments in teleconferencing products that do not support clear market-leading standards.

There may also be cases where international standards are approved and incorporated into the adopted profiles but are not market successes. There is a reasonable chance, for example, that any LAN-based teleconferencing standard that requires major investments in new LAN technology will not be a market success simply because the teleconferencing requirement is not of sufficiently high priority to justify the expense by end users, even if vendors are offering products that meet the standard. In particular, if the purpose for the new technology is only to support video, it might reasonably be argued that audiographic teleconferencing will suffice. If DoD jumps out in front of the market, it is taking a risk that it will end up with a lot of obsolete LAN technology. That risk may be appropriate in some cases, but it should be minimized in the same way that the use of proprietary technology is.

APPENDIX A. Desktop Teleconferencing Products

Most of the commercially available desktop video and audiographic teleconferencing products are listed in Table A-1. The table is up-to-date as of July, 1995, but there are new products coming on the market and vendors are releasing new versions with enhanced capabilities every day. The table indicates many of the aspects of each product to assist the prospective user or purchaser in narrowing the scope of the search.[6]

This study does not recommend specific products for teleconferencing. Such recommendations should be based on an evaluation that includes actual usage of the products, something that the authors are not equipped to support at the present time.

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[6] Much of the data in Table A-1 is taken from the Desk Top Video Conferencing Survey offered on the Internet at http://www2.ncsu.edu/eos/service/ece/project/succeed_info/dtvc_survey/survey.html. These entries are designated in the column labeled "Survey Info Updated" by either a date or a blank. Entries designated in this column by "ITCA" were added from product literature received at the Interactive Teleconferencing Association trade show in June 1995. The entry designated in the "Survey Info Updated" column by "Teleconf. Business" was taken from an advertisement in the May/June 1995 issue of *Teleconferencing Business*.

Table A-1. Desktop Video and Audiographic Teleconferencing Products

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
Armada	VCON, Inc.	PC (PCI)	IsoEthernet, T1, E1, ISDN, V.35, ATM	Ethernet, Token Ring, ATM	G.711, G.728	H.261	H.320, T.120, Group 3, 4		File transfer, OLE application swap, Shared whiteboard, toolkit	ITCA
AT&T GIS Vistium 1300	AT&T GIS	PC (ISA)	ISDN, Dual Switched 56, Dual V.35		G.728	H.261 (QCIF, CIF)	H.320	Yes	Whiteboard, application sharing of windows apps, file transfer, JPEG image capture	4-May-95
Avistar Conference	Avistar Systems	PC, Mac, Sun	ISDN, Switched 56, Fractional T1	Ethernet, TCP/IP				Yes	Document conferencing, shared whiteboard	29-June-95
Being There	Intelligence at Large	Mac	Ethernet, Token Ring, LocalTalk, POTS, ISDN, Other switched or dedicated digital telephone lines	Appletalk & ARA, TCP/IP	QuickTime	Quicktime, National Semiconductor Video Code		Yes	Full document window sharing, real-time updates of shared documents, whiteboard, drag/drop interface for file transfer, file & clipboard transfer, object based whiteboard mark-up tools	6-Jun-95
BVCS (Bitfield Video Communications System)	Bitfield Oy	PC	ISDN, TCP/IP, NetBIOS, T1/E1, Other	TC/IP, NetBIOS	G.711, G.722, G.728	H.261	H.320	Yes		8-Mar-95
C-Phone	Target Technologies, Inc.	PC	LAN, ISDN, Fractional T1, V.35, Switched-56	Netware, NetBIOS, Lantastic	Proprietary CLI PVE compression algorithm	Proprietary CLI PV2 compression algorithm		Yes	File transfer	ITCA
Cameo Personal Video System	Compression Labs, Inc.	Mac	Video over Switched-56, ISDN, Ethernet; audio requires separate or analog phone		Proprietary CLI PV2 compression algorithm	Proprietary CLI PV2 compression algorithm		No	File transfer	

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
Communicator III	EyeTel Communications, Inc.	PC	Switched-56, ISDN, T1, Ethernet, Token Ring	NetBois, TCP/IP, IPX	G.711, G.722, G.728	H.261	H.320	Yes	File transfer	
Communique!	InSoft	SunOS 4.1.3, 4.1.4, Sun Solaris 2.3, 2.4, HP-UX 9.0.3, 9.0.5, 10.0, IBM AIX 3.2.5, 4.1.1, DEC OSF/1, OSF/2, OSF/3, IRIX 5.3, SGI, IRIX 5.3, Intel PC, Windows 3.1, 3.11	ISDN, Frame relay, FDDI, SMDS, Ethernet, ATM	TCP/IP		CellB, JPEG, Indeo		Yes		30-May-95
ConferEase	Outreach Technologies	Windows, NT, Macintosh, OS/2, DOS, Unix				None	T.120	Yes	Slideshow (shared PowerPoint), toolkit	ITCA
Connect 918	Nuts Technologies	Mac	Analog, Switched-56, ISDN, Ethernet			G.711, G.722, G.728	H.320	No	Whiteboard, screen sharing	26-Apr-95
CU-SeeMe	Cornell University	PC, Mac	Internet	UDP/IP, IP Multicast		Non-standard		Yes, Using Unix reflector software	None	24-Apr-95
DECspin (DEC Sound Picture Information Network)	Digital Equipment Corporation	DEC	Standard network protocols	TCP/IP, DECnet				Yes, 2-8 participants	None	

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
DirectLink	Ogden Communications, Inc.	PC	28.8 Modem, Switched-56, ISDN, Ethernet, Token Ring	Unshielded Twisted Pair			H.320	Yes	Shared whiteboard	ITCA
Eris Personal Video Communications System	RSI Systems, Inc.	PC, Mac	ISDN, Analog	N/A	G.728, G.711, G.722	H.261 (QCIF, CIF)	H.320	Will support AT&T's WorldWorx	Real-time sharing of document window and file transfer capability	8-Jun-95
ES+F2F (Electronic Studio's Face 2 Face)	Electronic Studio	Mac	ISDN, Analog, Ethernet	Appletalk				No		
FarSite	DataBeam Corporation	PC	Analog phone, ISDN	IPX, TCP/IP		None	T.120	Yes	Shared workbooks	
ICU Video Services	Uni-Data and Communications, Inc.	PC, SUN, DEC	TCP/IP, UTP, ISDN, Switched-56, ATM, Private circuit	TCP/IP		H.261	H.320	4-, 9-, 16-way viewing with all participants simultaneously displayed	White pages, on-line directory service, text messaging, frame grabbing	14-May-95
InPerson	Silicon Graphics	SGI	ISDN, T1, Ethernet, FDDI	UDP/IP, TCP/IP		H.261, RGB8, HDCC		Yes		6-Jun-95
Interact	Applied Communication Concepts, Inc.	PC	ISDN, RS-449		G.711, G.722, G.728	H.261	H.320	Yes	Shared drawing areas, clipboards, file transfer, links, document camera, video playback	
InterDESK, VT2C	ABL	PC	ISDN, T1, E1, Switched-56, V.36		G.722. G.711. G.728	H.261	H.320		Shared applications, shared documents	ITCA
INTERVu	Zydacron, In.	PC	IsoEthernet, ISDN, Switched-56, V.35/RS366		G.711u/a, G.722, G.725, G.728	H.261 (QCIF, CIF)	H.320	Yes	File transfer, runs most collaborative software on market	

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
InVision	InVision Systems Corporation	PC	Ethernet, Token Ring, FDDI, Frame Relay, ATM, ISDN, V.32 or faster modem, Others	TCP/IP, IPX		DVI (Action Media II/ MediaShare Mambo)		Yes	VisionGraphics document sharing including whiteboard and OLE	
IVS (INRIA Videoconferencing System)	RODEO Project, INRIA Sophia Anitpolis, France	Unix	Internet	UDP/IP, IP Multicast	PCM, ADPCM, VADSPCM	H.261		Yes	None	28-May-95
LiveBoard	LiveWorks, Inc.	PC with 67" rear-projection screen, wireless pen	Analog phone, TCP/IP	NetBios, TCP/IP				Yes	Document conferencing, shared Windows applications	ITCA
Mediafone/ Fonewatch	Fiber & Wireless	PC	Analog/Digital phone lines, LAN, Internet; separate line for audio	Ethernet, Novell, TCP/IP				Yes LAN/ WAN	Whiteboard, application sharing	29-Mar-95
Meet-Me	SAT usa/ Sagem	Mac	IsoEthernet, ISDN	Appletalk	G.711, G.728	H.261	H.320		File Transfer, shared whiteboard	30-May-95
MINX	Datapoint Corporation	PC	Analog phone, ISDN, T1, E1, Swotched-56		G.711, G.722, G.728	H.261	H.320	Yes	Shared drawing areas, file transfer, links to external applications, document camera, video playback	
Ntv	Peregrine Systems	PC	Ethernet, Token Ring					Yes	Application sharing of Windows-based applications	
nv (Network Video)	Xerox/PARC	Sun SparcStation, DEC, SGI, HP900, IBM RS6000	Internet	UDP/IP, IP Multicast	N/A	Native NV, CU-SeeME, Sun CellB		Yes	None	26-May-95

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoper-ability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
Person to Person	IBM	PC	Analog phone, ISDN, Ethernet, Token Ring; audio requires separate ISDN or phone line	NetBIOS, TCP/IP, APPC, Novell IPX/SPX		DVI		Yes	Whiteboard, file transfer, talk window, shared clipboard	
Personal Viewpoint	Viewpoint Systems	PC	Analog phone, Switched-56, ISDN, Ethernet, Roken Ring	TCP/IP				Yes	Whiteboard, file transfer	
PICFON	Specom Technologies	PC	Analog phone, ISDN					Yes	Still-image sharing	
PictureTel Live PCS 100	PictureTel	PC	Switched-56, ISDN		G.721, G.722, G.728, PT 724 proprietary algorithm	H.261	H.320	Yes	Whiteboard, file transfer, screen sharing, application sharing	20-Feb-95
PictureTel Live PCS 50	PictureTel	PC	ISDN		G.721, G.722, G.728, PT 724 proprietary algorithm	H.261	H.320	Yes	Whiteboard, file transfer, screen sharing, application sharing	20-Feb-95
PictureTel LiveLAN	PictureTel	PC	LAN	IPX	Proprietary	Proprietary		No	Application sharing	20-Feb-95
PictureWin-dow	BBN	Sun SparcStation	Internet	UDP/IP, TCP/IP				Yes	None	
ProShare Video System 150	Intel	PC	LAN	NEtBIOS, TCP/IP, IPX, Ethernet, Token Ring, FDDI, T1, Frame Relay	GSM	Indeo			Whiteboard, application sharing	18-May-95

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
ProShare Video System 200	Intel	PC	LAN, WAN, ISDN	NetBIOS, TCP/IP, IPX	GSM, G.711	Indeo, QCIF, H.261	H.320	Yes	Whiteboard, application sharing	18-May-95
PSVC (Paradise Software Video Conferencing)	Paradise Software, Inc.	Sun SparcStation	ISDN, Ethernet, ATM	TCP/IP		M-JPEG		Yes	Whiteboard, video mail, screen capture	
ShareVision Mac 3000	Creative Labs	Mac	Analog phone				ITU-T H.324			6-Jun-95
ShareVision PC 3000	Creative Labs	PC	Analog phone		VATP	VATP	ITU-T H.324	No	Application sharing, whiteboard, document sharing, file transfer	6-Jun-95
ShowMe	Sun Microsystems	Sun SparcStation	Internet	UDP/IP, IP Multicast, RTP	G.711,	Cells	No	Yes	Whiteboard, application sharing for X11 R4/R5-based	26-Apr-95
TelePro	Specom Technologies	PC	Analog phone, ISDN					Optional	Document sharing of window applications through OLE	
TeleView 1000C	Video Conferencing Communications	PC	Analog phone							
Teles.Vision	Teles Corp.	PC	ISDN, V.xx modems	IPX			H.320, T.120	Yes	Applications sharing	
TeleWork-5	Vivo Software, Inc.								Document sharing, file transfer	ITCA
VCC	VCC Video Conferencing	PC	Analog phone, ISDN, Cellular, Ethernet, Internet, Others	Ethernet					Shared whiteboard, document sharing, application sharing	Teleconf. Business
VicPhone	VIC Hi-Tech Corporation	PC	Analog phone, ISDN, Ethernet			JPEG		Yes	Shared image/document/ workspace/chalkboard	

Table A-1. Desktop Video and Audiographic Teleconferencing Products (Continued)

Product	Provider	Platforms	WAN Protocols	LAN Protocols	Audio Encoding	Video Encoding	Interoperability Standard Support	Multipoint	Collaboration Features	Survey Info Updated
VidCall	MRA Associates, Inc.	PC	Analog phone, ISDN, Ethernet, Token Ring		Analog phone	Encoding Routines	No	Yes	Whiteboard, image sharing and annotations, application sharing via OLE	13-Mar-95
VideoVu	Future Communications Systems, Inc.	PC	Analog phone, LAN, Internet					Yes LAN/WAN		26-May-95
Virtual Desk	Imagelink	Unix	TCP/IP, Ethernet, ATM, SMDS, FDDI	Ethernet	G.711, G.722, G.728	H.261	H.320	Yes	Shared whiteboard, shared graphics files applications	ITCA
Virtual PC	Imagelink	PC	ISDN, T1, Switched-56, Frame Relay, SMDS, ATM	NetBIOS	G.711, G.722, G.728	H.261	H.320	Yes	Shared whiteboard, shared graphics files applications	ITCA
VISIT Video	Northern Telecom, Inc.	PC, Mac	ISDN, Switched-56; audio requires separate line			H.261	Future versions promiss H.320 compliance	No	Whiteboard, file transfer	25-Apr-95
Vivo320	Vivo Software, Inc.	PC	ISDN		G.711, G.722	QCIF/CIF	H.320	Yes	Document sharing, image presentation and markup	30-May-95
VS1000	Mentec International, Ltd	PC			G.711	H.261				
VTEL	VTEL	PC			G.711, G.722, G.728, 32Kbps and 12Kbps proprietary	H.261	H.320	Yes	Document conferencing, computer conferencing, video mail	

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13. ABSTRACT (Maximum 200 words)

Teleconferencing is a mechanism for supporting interactions among two or more people, where the participants are interacting at the same time but not all in the same place. Desktop teleconferencing requires that at least one of the participants is using a desktop computer system as the teleconferencing system. This document identifies the role of standards in teleconferencing, identifies existing and emerging standards, and points out areas where the standards activities are not yet coalescing. Many vendors have been, and promise to continue to be, quick to adopt standards as they stabilize. In areas where standards are not stable, there are proprietary products that do not provide interoperability. The document also identifies local area network (LAN) technology as one area where standards may not be enough to ensure the long-term viability of products, since there are numerous competing technologies and demands other than teleconferencing that will influence acquisition decision for LANs. DoD has officially adopted in a video teleconferencing profile some of the stable standards. This document recommends continued use of that profile for situations where it applies. The official profile, however, does not meet all DoD requirements. The document also provides recommendations on how to deal with other DoD requirements.

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