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Videoconferencing and its role in the Army

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VIDEOCONFERENCING AND ITS
ROLE IN THE ARMY

by

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June, 1994

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The current family of videoconferencing equipment is reviewed and current standards that govern videoconferencing are examined. Videoconferencing systems are described in both a tactical and garrison environment with an emphasis on bandwidth requirements, survivability, and system security. Also, current tactical examples of videoconferencing use are discussed to provide insight as to the possible future uses of systems. Currently videoconferencing systems are used for staff planning, videomedicine, and videotraining.

Finally, a projected videoconferencing architecture for a corps/division is analyzed with possible locations of the videoconferencing sites and communication systems that could link the videoconferencing sites together. A breakdown of possible users is provided to show that videoconferencing can play a successful support role in the Army.

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Videoconferencing and Its Role in the Army

by

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ABSTRACT

This thesis discusses the capabilities and the requirements for integrating videoconferencing technology into the Army's communication system. As the bandwidth requirements for videoconferencing are lowered and the bandwidth availability increases, it is becoming more feasible to incorporate a videoconferencing system into a commander's communication structure.

The current family of videoconferencing equipment is reviewed and current standards that govern videoconferencing are examined. Videoconferencing systems are described in both a tactical and garrison environment with an emphasis on bandwidth requirements, survivability, and system security. Also, current tactical examples of videoconferencing use are discussed to provide insight as to the possible future uses of systems. Currently videoconferencing systems are used for staff planning, videomedicine, and videotraining.

Finally, a projected videoconferencing architecture for a corps/division is analyzed with possible locations of the videoconferencing sites and communication systems that could link the videoconferencing sites together. A breakdown of possible users is provided to show that videoconferencing can play a successful support role in the Army.

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I. INTRODUCTION

The Army's command, control, and communication (C^3) systems are constantly being improved and upgraded to provide a better system for the commander. With recent improvements in video technology, now is the time to implement a videoconferencing system that the commander can use in both a tactical and garrison environment. In today's high-technology Army, commanders must have the capability to manage time and resources with the best equipment available. This must also be conducted within the limits of a shrinking budget and a military drawdown.

Time is the greatest factor that affects planning and operations for the commander and staff. Videoconferencing systems have already gained wide acceptance in the business community as an excellent time-saving command and control tool. Videoconferencing allows face-to-face meetings to occur between individuals or groups that are geographically separated.

Videoconferencing systems are currently in use at numerous Army installations within the continental United States, the Pacific Theater, and Korea. The systems that are in use are garrison or fixed location systems that have no tactical capabilities. Development and future use of videoconferencing systems is presently at a crossroads in the Army. Future systems must be both garrison and tactical capable and compatible with existing systems. Important doctrine has yet to be written concerning future videoconferencing use.

A. INTENT OF THESIS

This thesis will examine current and future uses of videoconferencing capabilities for tactical and fixed environment military forces. The primary research question is: Can Videoconferencing be used in a fixed and tactical environment to support the commander in the areas of command and control, staff support, videomedicine, and videotraining? The videoconferencing system should provide these capabilities at a level that can be supported in both environments (fixed and tactical) with equipment and personnel that are presently assigned.

There is currently no document that provides a plan or an architecture to use videoconferencing capabilities within a fixed or tactical environment. The lack of a plan or standards has already caused interoperability problems to occur within all branches of the military. As different CINC's initiate videoconferencing within their command, several different systems are being used over several different transmission mediums. Thus many systems are unable to talk to other videoconferencing systems from different commands.

On top of this problem, many systems have been purchased that do not have the capabilities to work in a tactical environment. The tactical environment is the area where videoconferencing systems have the potential to provide the greatest impact. This thesis will also examine the changes being made in the equipment and the transmission mediums. Finally, a videoconferencing architecture will look at how current systems can be employed in the tactical environment to provide medical support, distance learning and staff support with greater efficiency and at a reduced cost.

B. DISCUSSION OF CONTENTS

Following the introduction, Chapter II introduces video compression, videoconferencing equipment, current standards for videoconferencing equipment, and transmission mediums used in videoconferencing networks. This background allows the reader to gain a basic understanding of the technical aspects of video transmission systems. The coder-decoder (codec) is discussed in some depth because it is the heart of all videoconferencing systems. Appendix A and Appendix B also provide a more in-depth background on video transmission and T1 networking systems. These appendices are provided for the reader who has little or no background in video transmission systems.

The next chapter discusses videoconferencing in the Army and problems that are associated with current systems. The requirements of future systems and the interoperability problems of current and future systems are examined to provide the reader an idea of shortcomings that affect videoconferencing systems. An overview of available off-the-shelf commercial equipment is provided. The systems are divided into three categories which are small roll-about systems, medium roll-about systems, and full room systems. This is done to provide the reader with an idea of the size and mobility of the current videoconference systems in use in the Army. The chapter concludes with a discussion on the tactical and garrison requirements of dual purpose videoconferencing systems. Issues such as bandwidth requirements, survivability, and system security are discussed and recommendations are introduced to make videoconferencing systems usable in a tactical environment.

Chapter IV discusses tactical examples of videoconferencing use. Video staff planning, video medicine, and videotraining are currently the primary uses for videoconferencing systems. An example scenario is provided for video staff planning and video medicine. Both of these scenarios were conducted in a tactical environment, which provides a framework for the videoconferencing architecture developed later in the thesis. Videotraining and its benefits are discussed to conclude this chapter.

The fifth chapter is used to develop a videoconferencing architecture for a corps or division size element. This chapter is used to incorporate the information discussed in the two proceeding chapters. An overview for a corps and a division are provided, and a organizational chart of a corps and a division are provided in Appendix E. A videoconferencing architecture for a corps is discussed initially. The primary topics are the location of the videoconferencing systems, the users, and the communications systems that can be used to connect the videoconferencing network. The corps rear command post, corps main command post, and the corps tactical command post are the locations that are examined. Next, the chapter examines the division and develops a videoconferencing architecture for its use. Locations of videoconferencing systems and communications links provide a network that supports the needs of the division staff and commander. Finally, possible usage of a tactical videoconferencing system and the use of videoconferencing as a command and control tool are discussed. Command and staff relationships and the role tactical videoconferencing plays in a corps/division is the conclusion of Chapter V.

II. VIDEO COMPRESSION, EQUIPMENT, AND STANDARDS

A. VIDEO COMPRESSION

This thesis assumes that the reader has a previous knowledge of digital communications, signal transmission and video theory. The video transmission primer (Appendix A) is provided as a simplified primer on the principles of video transmission. Should the reader feel that more background information is needed, the books entitled *Telecommunications Transmission Handbook,* 3rd Edition, by Roger Freeman and *Electronic Communications Systems* by William Stanley provide more detailed information on the subject. (Jolley, 1992, p.8)

Bandwidth, cost, and interoperability provide some limitations to current videoconferencing capabilities, but bandwidth provides the major limitation to current and future videoconferencing capabilities. Full motion video requires that a large amount of information must be transmitted in a short amount of time, thus a large amount of bandwidth is required for analog full motion video. The transmission bandwidth is defined as the amount of bandwidth that "..is just enough to ensure the transmission of information at the rate and quality required under specified conditions." (Langley, 1982, p.16) In order to transmit analog full motion video that has not been compressed and digitized requires a transmission medium equal to a full satellite transponder. (Jolley, 1992, p.9)

The advent of digital signal processing did not immediately reduce the large bandwidth required for full motion video signals. In fact, the cost and bandwidth requirements increased because digital full motion video required a transmission bandwidth of 80 Mbps or more. What digital technology did provide was the ability to use video compression techniques to reduce the bandwidth required to as little as 56 kbps. (Jolley, 1992, p.9)

B. EQUIPMENT

A current videoconferencing system consists of several key items including a video camera or video input device, a video coder-decoder (codec), a video multiplexer-demultiplexer (mux/demux), and a network adapter. The video input device simply captures the picture (either still or motion) and then routes it to the video codec. The video codec is the most important piece of equipment in the videoconferencing system because the codec provides the video compression that reduces the bandwidth to the lowest bit rate possible. The codec will be discussed in greater depth in the next section. The mux/demux simply breaks the coded message up into packets or frames depending on whether Time Division Multiplexing (TDM) or Pulse Code Multiplexing (PCM) is used and then sends the digital signals to the network adapter which sends the signal out to the distant end.

1. Video camera and monitor

The camera must comply with CCITT recommendations specifying that a video signal of 625 lines per frame and 50 fields per second be available. Each frame contains two fields and therefore results in a frame repetition rate of 25 hz. In a videoconference studio all cameras must be synchronized. This requirement could require external synchronization. To ensure the best picture possible, it is recommended that the users determine the intended use (either still picture or motion picture) and use the appropriate camera setup.

The monitor must also comply with the same CCITT recommendations required for the video camera. Monitors should also have a vertical resolution of at least 400 lines, and the screen size used must be maximized in relation to the viewing distance in order to provide proper viewing.

2. Codec Functionality

Video codecs perform the following functions:

1. Analog-to-Digital conversion of audio, full-motion video, and still graphics video signals.

2. Digital video signal (full-motion and graphics) demodulation.

3. Digital video signal (full-motion and graphics) coding and bandwidth reduction.

4. Digital audio time delay.

5. Multiplexing of the digital audio, full-motion video, still-graphics video, and data samples.

6. Encryption of the multiplexed signal.(Inglis, 1988, p.18.6)

The codec employs an algorithm, usually proprietary, to carry out the process of encoding and compressing analog signals. Initially, the incoming signal is converted to a digital signal. After this digital conversion is complete, the codec performs a series of bandwidth compression algorithms and digital coding procedures. (Jolley, 1992, p.10)

Two techniques for data reduction are frame elimination and field (or pixel) elimination (For further explanation of a pixel and a video frame refer to Appendix A). Field elimination requires the removal of either the even or odd numbered pixels that compose a video frame. By employing field elimination the number of pixels is reduced by one-half. Frame elimination requires a reduction in the overall number of frames to be encoded. This process is accomplished by monitoring the changes in a frame and then eliminating any frames where little or no change occurs. Frame elimination will also update only the changes made to a frame and not the entire frame.

Field and frame elimination techniques are limited by the amount of motion that occurs in the video. If a large amount of motion occurs, the picture quality may not be to the desired specifications due to the data compression techniques employed. By employing frame and field elimination, a digital video signal can be reduced from 80 to 95 percent. (Inglis, 1988, p.18.8)

A tradeoff between the bandwidth and the picture quality occurs within the codec when video is compressed. The motion-handling capacity and picture resolution are reduced when the bandwidth is lowered. To overcome this problem, more sophisticated encoding techniques are required as the bandwidth is lowered. The transition from medium to high motion video may still cause picture inconsistencies to occur. (Jolley, 1992, p.13)

Graphics are usually transmitted in still motion form. Graphics are compressed in space just like full-motion video and transmitted one frame at a time by interleaving a single graphics frame within the full-motion video frames. The graphics frame is then displayed at the receiving end while the audio signal continues to be transmitted. When the graphics image is no longer needed at the receiving end, the full motion video signal returns. This allows the person at the transmitting end to be seen and heard on the full motion video, then display a graphics image and talk through the graphics. After explaining the graphics image, the person can return to the full motion video. (Inglis, 1988, p.18.9)

In order to synchronize the audio signal with the video signal, the codec uses a time-delay procedure. Once this is performed, the audio, video, and data signals are multiplexed, encrypted, and then transmitted to the distant station. (Inglis, 1988, p.18.8)

C. STANDARDS

Since videoconferencing has changed so much during the last couple of years, there has been great effort to establish standards that reduce any problems with interoperability between users of different systems. Currently the two main standards involving videoconferencing are H.261 and H.320 of the CCITT. Another standard that is gaining more acceptance in the video industry is Motion Picture Expert Group (MPEG) of the International Standard Organization (ISO).

1. H.261

The H.261 standard is based on an ISDN transmission medium where H.261 = p x 64 kbps/second and p = 1,2,...30. For p = 1 to 6 (56 to 384 kbps)[1] only point to point conferencing can be used. If p is greater than or equal to 6 (384 kbps or greater), then multiperson videoconferencing is available, but more bandwidth is required.

The H.261 video coding algorithm uses both intraframe and interframe coding schemes. It is a hybrid of the Discrete Cosine Transform (DCT) and the Differential Pulse Code Modulation (DPCM) schemes with motion estimation. In the

[1] The cutoff point between point to point and multipoint videoconferencing is 384 kbps. Thus, 384 kbps is listed as point to point and multipoint videoconferencing systems.

interframe coding mode the DPCM is in operation. The prediction is based on motion estimation by comparing every block of the current frame with the corresponding blocks of the previous frames. If the difference between the blocks is less than a certain threshold, no data is transformed for that block. If the difference is greater than the threshold, the difference is DCT transformed, linearly quantized and then sent to the video multiplexer and coded together with motion vector information. The step size of the linear quantizer can be adjusted depending on the fullness of the transmission buffer of the encoder. During the intraframe mode, the DPCM is not operative. Every 8 x 8 block in a picture frame is transformed into DCT coefficients, linearly quantized and then sent to the video multiplex coder. The same picture frame is also recovered through the inverse quantizer and inverse transform and stored in the picture memory for interframe coding. The CCITT H.261 video coding algorithm covers a wide range of bit rates for various real time visual applications. The picture quality as well as the motion effect varies depending on bit rate used.

2. H.320

The H.320 standard is a family of standards covering audio and video compression and decompression, encryption, multipoint conferencing, and graphics. This standard covers the total spectrum of videoconferencing from 64 kbps to 1.92

Mbps. This standard is designed to solve the interoperability problem between equipment produced by different manufacturers.

D. TRANSMISSION MEDIUMS

Currently there are several equally popular types of transmission mediums. The only constraints being bandwidth available and current cost. The different types of medium are T1, ISDN, B-ISDN, and DCTN.

1. T1 Network

Appendix B provides an understanding of T1 systems and structure. In other sections of this thesis a reference will be made to T1 capabilities of the codec, videoconferencing systems, and military communications systems in terms of transmit and receive capabilities. T1 transmission facilities operate at digital signal rate DS1[3] with a data rate of 1.544 Mbps. The most important advantage of T1 is the bandwidth capacity. It is possible to order bandwidth on demand or a partial T1 in order to cut costs. The majority of the codecs operate at low bandwidth (56 to 384 kbps) for a lower cost and thus a partial T1 is needed instead of a full T1 circuit. High

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[3] DS0 is the nucleus for the digital signal designations. The DS0 voice-digitation rate (VDR) is 64 kbps. 24 DS0 channels are required for a T1 and are defined as DS1 with a VDR of 1.544 Mbps.

bandwidth codecs operate between 384 to 1.544 Mbps for high picture quality videoconferencing.[1] (Jolley, 1992, p.15)

2. ISDN and B-ISDN

Integrated Services Digital Network is defined as a network that provides end-to-end digital connectivity that can support a wide range of services to include voice, data, and video. B-ISDN or Broad Band ISDN is of main interest for video systems. B-ISDN allows the users to have bandwidth on demand by simply calling the phone company and ordering the needed bandwidth during a specific time period. This service would allow a video user to request a 128 kbps circuit to do a videoconference with another user for one hour and be charged for only that amount of time and bandwidth. This dial-up capability makes videoconferencing more available and less expensive to use.

3. Defense Commercial Telecommunications Network

Defense Commercial Telecommunications Network is a large digital integrated voice/video/data network that AT&T is providing for the Defense Information Systems Agency (DISA) on a ten year contract which began in 1990. The DCTN is the designated transmission medium for all approved Army videoconferencing projects. (DISA, 1993, p.41) The system is managed and controlled by AT&T from the network control center

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[1] The cut-off point between low-bandwidth and high-bandwidth videoconferencing is 384 kbps. Thus, 384 kbps is usually listed on both low-bandwidth and high-bandwidth codecs.

in Drainsville, Virginia and interfaces with DISA through the DISA operations center in Arlington, Virginia. The system is tightly managed in order to integrate existing operations and provide real-time network status, as well as a single point of contact to the user. Videoconferencing is being provided at the DS1 rate of 1.544 Mbps because partial T1 rates are not yet available on DCTN. The system consists of two-point videoconferencing and one multilocation system. Appendix C contains a current list of videoconferencing systems on DCTN.

III. VIDEOCONFERENCING IN THE ARMY

Videoconferencing is a major advance over the traditional conference call in that it allows both visual and audio communications. There is a need in today's Army to simulate face-to-face meetings[1] for geographically separated organizations. The time and money lost to travel is non-productive and causes a fiscal strain on the shrinking budget. Videoconferencing decreases the lost time spent traveling and increases the productivity of the personnel involved by allowing them to remain at their primary duty station during time that might have previously been spent traveling. It also allows a wider range of personnel to become involved in planning and training. There are currently 54 videoconferencing sites (See Appendix C) within the Army structure. Most of these sites have been installed within the last few years and, so far, have received little use. The use of videoconferencing equipment as a tactical command and control tool is just beginning to be discussed and could prove even more beneficial to the Army than garrison-only videoconferencing.

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[1] For the purposes of this thesis, face-to-face meetings will be defined as physical interaction. All other face-to-face interaction will be electronic and will simulate an actual meeting.

A. SUMMARY OF THE VIDEOCONFERENCING PROBLEM

Videoconferencing currently is the most facilitative solution to Army's current requirement for face-to-face meetings for dispersed groups. Much effort has been put forth to establish a system of videoconferencing centers and networks at garrison locations, while little effort has gone into the establishment of tactical videoconferencing capabilities. Both systems should be developed together. Used in coordination, both systems could form an effective command and control tool for use by the commander in all environments and from any location.

1. Current Status

As of January 1994, there has been very little work conducted in the area of tactical videoconferencing. This is due in large part to the lack of interest in videoconferencing in general shown by the commanders at all levels within the Army. A large part of this lack of interest is due to the slow development of standards and doctrine within the Army on the use of videoconferencing. The commander has little concern for administrative command and control equipment that can not also be used in a tactical environment.[1] A videoconferencing system that can be used in a garrison environment and then transported to a tactical environment would be more practical

[1] This information was gathered from conversations with the DCTN managers of the TRADOC, FORSCOM, and HQDA videoconferencing networks.

and useful to the Army commander. Systems that can be operated in tactical and garrison environments will be considered dual purpose systems. Single purpose systems will refer to those systems that can operate in a garrison environment only. Is there a need for a dual purpose system as a command and control tool? As stated by the Army's Enterprise Strategy "the goal of this strategy is to support the warfighter in combat and garrison."(Sullivan, 1993, p.1) With increased requirements to existing command and control systems, videoconferencing systems can provide an improvement to existing command and control systems.

a. Future Requirements

With the reduction of forces and the shrinking budgets that the Army is facing, now is the time to act on a dual purpose videoconferencing system. The demand for units to be deployed as a task force away from the normal support structure will only increase if the size of the Army continues to decrease while the missions of the Army continue to increase. With a dual purpose system, a division commander could deploy a portion of his division forward and then link back to the rear through videoconferencing. This would allow the division staff to provide support for the forward and rear deployed units simultaneous. Some probable scenarios for the usefulness of dual purpose systems will be discussed in depth later in the thesis. Videoconferencing would allow the tactical commander to simulate face-to-face meetings with a geographically dispersed staff, which would give the commander a virtual battle staff regardless of the commanders location.

b. Interoperability Issues

Due to slowly developing standards within the Army and DOD, an interoperability problem has already begun to develop with videoconferencing systems already in use. The bulk of this problem comes from organizations purchasing different systems that are not interoperable. Solutions to these problems are not easily found and are very expensive. Most of the interoperability problems stem from units operating at different bandwidths, old systems not interoperable with newer systems, and a lack of procurement guidance for future purchases. DISA has been tasked with the responsibility of solving these problems. Once a clear set of standards and a videoconferencing doctrine is published most of these problems should be corrected. (McDonald, 1993, pp.1-3)

B. CURRENT VIDEOCONFERENCING EQUIPMENT

Videoconferencing equipment comes in many forms and styles with price, number of users, bandwidth requirements, ease of use, and size as the major points of concern for dual purpose and single purpose units. Videoconferencing equipment can be divided into three groups of systems: small roll-about systems, large full room systems, and midsize roll-about systems. The three major producers of videoconferencing equipment are Compression Labs Inc (CLI), Picture Telephone (PICTEL), and VTEL. Compression Labs is recognized as the world leader in videoconferencing sales and distribution (Sullivan, 1990, p.1). The product line most frequently in use in the Army is Compression Labs, but no one system has a sole provider contract with the Army.

1. Small Roll-about Systems

The small roll-about system has the greatest potential for tactical use in the Army. The system is small but still provides excellent quality full motion video. Most small roll-about systems have one monitor that ranges in size from 20 to 27 inches. The systems have software driven codecs that can run on a 386 or 486 computer. Most systems, including monitor, are about 4 feet tall, 3 feet wide and weigh about 150 pounds. The systems are portable and can be used in a tactical or garrison environment. Two systems that are currently in use in the Army are the Compression Labs Eclipse and the VTEL VP125.

a. Eclipse Small Group System

The Eclipse system is a small roll-away system that is remarkably easy to use. The system comes assembled so plugging it in is all that is required. The system is the first videoconferencing system to use a remote control and offer a graphical interface. The graphical interface uses on screen messages and icons that correspond to icons on the remote control unit. The Eclipse is contained in a portable cart and is equipped with a 20 inch monitor. The Eclipse is also multipoint ready with the capabilities of linking 28 different sites into one round table videoconference. (CLI, 1993, pp. 1-4)

The main strong points for the Eclipse system is that the user does not have to sacrifice picture quality for a portable capability. The system can run on many different types of transmission media such as DCTN, ISDN, B-ISBN, and dedicated services. The system also has the capabilities to incorporate a VCR and a integrated satellite receiver/ decoder for those users that wish to receive broadcast distance learning programming. The price of the Eclipse system ranges from $14,500 to $19,900, which is 50 to 70 percent less than comparable systems. The system can also be leased for $450 to $600 a month which, for maintenance reasons, most readily meets the needs of the Army. (CLI, 1993, pp. 1-4)

b. VTEL VP125

The VP125 is an easy to use roll-about system. The system has a 25 inch monitor and a software driven codec that can run on a 386 or 486 computer system. The system can support a full T1 circuit (1.544 Mbps) and uses a remote control interface for easy system use. The system is multipoint conference capable when attached to a Multimax II. The Multimax II is a multipoint videoconference control unit that allows 20 sites to be linked together. The system also uses automatic voice-activated video switching and directed chairperson control. (VTEL, 1993, p.1)

2. Full Room Systems

Most videoconferencing sites within the Army are full conference room systems that are large in size and cannot be tactically deployed. Most room systems have multiple monitors and cameras and require large hardware driven codecs. The full room videoconferencing systems are usually located at the division headquarters or garrison headquarters of the sites listed in Appendix C. The two systems that are currently in use in the Army are the Compression Labs Rembrandt family of equipment and the VTEL BK227 and BK235.

a. Rembrandt Family of Equipment

The Rembrandt family of equipment is the most widely used system of the DCTN. The Rembrandt™ family consists of the Rembrandt, Gallery, Rembrandt II/06, and the Rembrandt II/VP. The Rembrandt systems dominate the high-bandwidth (384 kbps-2.048 Mbps) videoconferencing market. The Rembrandt system is used in most full size videoconferencing rooms that require high quality video. The Rembrandt II/VP is the system that is currently in use in most of the videoconferencing sites within the Army. The Rembrandt system has the capabilities to operate at transmission rates as low as 56 kbps if necessary. The Rembrandt II/VP was the first full size videoconferencing system to fully incorporate the H.261 standard. (CLI, 1993, pp. 1-4)

b. VTEL BK227 and BK235

The BK 227 and 235 series videoconferencing systems provide full room videoconferencing at bandwidths ranging from 56 kbps to 1.544 mbps. The system is a full feature system that uses a custimizable user interface with features such as an enhanced graphics and real time remote diagnostic features for analyzing and troubleshooting system performance even while conferences are in session. The system can mulitpoint conference with 20 different sites and also has the capability to utilize a function called document conferencing. Document conferencing allows a person to fax documents to all participants in a multipoint videoconference so that work can be conducted simultaneously. The system includes two 27 or 35 inch monitors and a hardware driven codec. The system also has a computer conferencing feature that allows two participants to work on a computer document in real time without interrupting the conference. The last feature of the system is time conferencing. This allows a one minute video message to be recorded and reviewed later.(VTEL, 1993, p.1)

3. Midsize Roll-about Systems

The midsize roll-about system can also be used in a dual purpose videoconferencing capability. These systems can have one or two monitors and are a little larger than the small roll-about systems. Currently, the Compression Labs Radiance system is the only midsize roll-about system on the market. The Radiance is a recently released product (January 1994) and is designed to provide videoconferencing capabilities between the Rembrandt and the Eclipse family of systems. Much the same as the Eclipse system, the Radiance is a roll-about system with greater capabilities such as a 27 inch monitor, enhanced graphics capabilities, touch screen control, and 30 frames per second resolution. With the touch pad interface, the system is extremely user friendly and requires little training. The system is interoperable with the Eclipse and the Rembrandt and is multipoint ready upon delivery. The system includes a graphic cam that allows 10 to 1 zooming which enables still-image graphics to be viewed up close. The price range on the Radiance is $45,000 to $58,000. (CLI, 1993, pp. 1-4)

C. TACTICAL VERSUS GARRISON REQUIREMENTS

The different requirements for a tactical videoconferencing system and a garrison videoconferencing system cause a problem when attempting to design a dual purpose system. Issues that affect the quality and use of tactical and garrison videoconferencing are bandwidth limitations, survivability, and system security. Although, cost is also a factor that affects the systems, it is difficult to access operational cost in a tactical environment because it is a physical cost rather than a dollar cost, and therefore will not be a factor discussed.

1. Bandwidth Requirements

Bandwidth control and bandwidth management are the most important factors when planning a tactical and garrison videoconferencing system. The amount of bandwidth that is available for videoconferencing is the most important factor in the quality of the picture. The best picture resolution is achieved by using the highest bandwidth that is available. However there are certain trade-offs with using higher bandwidth such as cost and less bandwidth available for other circuits.

a. Tactical Bandwidth Requirements

Due to the limited amount of communications equipment and communications medium that are available in the tactical environment, bandwidth is a closely monitored asset. Because tactical communications are currently utilizing current capacity, finding the bandwidth to use for tactical videoconferencing will require some difficult decisions to be made by commanders and communicators. Because of this bandwidth limitation, tactical videoconferencing is required to operate at the lowest bandwidth possible to achieve full motion video. Currently the lowest bandwidth is 128 kbps. The Army's tactical communications systems that can transmit tactical videoconferencing are the TSC-85 and TSC-93 tactical satellite systems. The TSC-85 has 24 channels that can transmit 32 kbps per channel and the TSC-93 has 12 channels that have a 32 kbps per channel capacity. To conduct a videoconference on these systems would require a minimum of four channels. This would then affect the capabilities of this system to continue voice communications as long as a videoconference is being conducted. The commander must feel that this loss is worth the benefits of videoconferencing as a command and control tool.

b. Garrison Bandwidth Requirements

The bandwidth problems that occur in a tactical environment do not trouble a commander in a garrison environment. Since bandwidth is readily available, it is simply a matter of the commander deciding what to spend on videoconferencing. A point to point system between users should require no more than 128 kbps at each point. For a better picture quality, the commander may require 384 kbps or 512 kbps. The videoconferencing system also requires that both systems in a point-to-point mode operate at the same bandwidth. Multipoint systems require at least 384 kbps of bandwidth to meet the minimum requirements. All of this is available if the organization can justify the cost. Most of the systems on the DCTN videoconference net (see Appendix C) operate at 384 kbps but have the flexibility to *change* rates when necessary.

2. **Survivability**

Survivability of the videoconferencing system is mainly the concern of a tactical system. The only survivability concerns for a garrison videoconferencing system are maintenance and location. Ensuring that the system is stored in a proper location that allows the system to be used but not damaged during installation is important. The garrison videoconferencing system may also be moved around. Thus it should have a proper means of transportation within the primary location. Movement capability in a tactical environment is also important in a dual purpose system.

A videoconferencing system in a tactical environment has several concerns including transportation of the system, keeping the system clean, and hardening the components of the system to prevent accidental destruction of the equipment. To transport the system a hardened case must be designed to prevent damage to the system during transport to a tactical environment. Since this has already been done for computer systems, it should not pose a problem. The next issue is keeping the system clean and dry in order to prevent most maintenance problems that occur when a system gets wet or dusty inside. The system should be set up in the command center and be kept covered when not in use. The command center at the JTF and Division level has the capabilities to provide an environment where the system could be set-up and operated without much threat to the components of the system. The last area of concern to the survivability of the system is the hardening of the individual systems to survive the day-to-day rigors in the Army. An organization in a tactical environment could move the operations center as frequently as every 48 to 72 hours. This set-up and breakdown of the command center and the videoconferencing system could lead to numerous equipment problems if the equipment is not hardened. Although this is possible, it could be expensive. Thus it may not be feasible to harden all the components. Perhaps only the most delicate items such as the codec and mönitor could be hardened. Another possibility is installing the video equipment in a van and then remote the camera and monitor into the command center. The permanent installation of videoconferencing systems in vans removes the flexibility of a dual system because the system is a tactical system only.

3. System Security

With the introduction of videoconterencing systems as a command and control tool, new security issues will also be introduced. As with current command and control systems, the commander will discuss sensitive issues but unlike old command and control systems, a message intercepted by the enemy could reveal factors such as stress, fatigue, confidence and the overall personality of the commander. To see video of a commander could reveal a side of the commander not understood by listening to voice alone. Because of the added risk involved with interception of a videoconference, it is key that the signal be protected the entire route of both tactical and garrison videoconferencing.

a. Site Security

Site security is a concern of both tactical and garrison videoconferencing systems. In a tactical environment the system must be located inside a site that requires an access badge and is guarded 24 hours a day such as the division tactical operations center (TOC). Access to the videoconferencing equipment should be on a need-only basis. In garrison, the videoconferencing system should be located in the division or corp conference room and locked with a cipher lock to restrict access.

b. Transmission Security

In order to provide transmission security in a tactical environment, security of the system must start at the transmitting codec and end at the receiving codec. This can be accomplished by installing a KG-81 or KG-94 secure device on the line leading from the codec on both ends of the system.[6] The transmission system has secure capabilities installed that insure that the system is secured between transmitting and receiving station. The TSC-85 and TSC-93 use the KG-31 secure device as the primary means of transmission security. With the

[6] The TSC-85 or TSC-93 are currently the only Army tactical communications systems that can be used to transmit full motion video without interrupting the voice channels.

configuration listed above, the tactical videoconferencing system will have end-to-end transmission security. The only variation with the garrison videoconferencing system is with the use of dedicated lines on DCTN. A KG-81 or KG-94 is not required on a dedicated circuit but it is recommended to ensure that no unauthorized intercept occurs. Currently there is no specified guidance on transmission security of a dedicated circuit.

IV. CURRENT TACTICAL EXAMPLES

A. VIDEO STAFF PLANNING

1. Staff Support

The role of the staff officer is expanding rapidly as the Army continues to drawdown and the missions of the Army continue to change. As stated in the Army Enterprise Strategy, The Vision, the full integration of the staff officer to perform duties in both garrison and tactical environments is critical. The Vision also supports the full integration of supply and transportation functions into a vertical distribution system, with logistics and transportation management functions to be accomplished from a garrison environment, deploying only those functions that are necessary. This is called split-based operations. In these operations, the staff officer located in a garrison environment receives the requirements and then sends forward the necessary support. Split-based operations reduce the burden on the deployment flow and prevent unnecessary stockage of equipment and personnel within the theater of operations. (FM 100-5, January 1993, p.43) The staff officer is continually being required to plan and organize missions at the Army and JTF level. Planning done with other staffs that are located hundreds and even thousands of miles away is increasing the need for videoconferencing in both the tactical and garrison environments. Staff officers, as a group, are quickly embracing the use of videoconferencing at all levels. This is verified by the usage logs of the FORSCOM videoconferencing net which show that, for the months of February and March 1994, 99% of the videoconferencing activity was conducted by staff officers during planning. Most of the activity was conducted by the administration and logistics personnel. Exercise planning still receives very little videoconferencing time. Most of this planning is still done in person.[7] The main reason for this could be the lack of a tactical videoconferencing system. As staff planners become more comfortable with videoconferencing used as a planning tool, more commanders will incorporate videoconferencing in garrison and tactical planning conferences. (McCleary, 1994, pp.1-15)

2. Example Scenario

A dual purpose videoconferencing system, the Theater Automated Command and Control Information Management System (TACCIMS) videoconferencing support system or TVSS, was utilized during exercise Ulchi Focus Lens (UFL)93 in the Republic of Korea (ROK). The technical details of the TACCIMS

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[7] Through examination of the FORSCOM videoconferencing logs and telephone interviews with FORSCOM and U.S. Army Pacific Operations Cells, the planning for all exercises is still performed over the telephone and with face-to-face meetings.

system are not important here. It is used in this thesis as an example of videoconferencing. For those interested, the capabilities and technical characteristics of the TVSS are discussed more in depth in Appendix D. The TVSS network in Korea consists of more than twenty (20) sites including the wartime headquarters, Command Post Tango; the U.S. Forces Korea rear headquarters, Site Oscar; the Air Component Commander at Osan Air Base; Command Center Seoul; Combined Unconventional Warfare Task Force (CUWTF); the Naval Component Commander on the USS Blue Ridge, the Seventh Fleet flagship which was located at sea; the Republic of Korea (ROK) VII Corps; and U.S. Forces Japan. (ISMA, 1993, p.1)

The TVSS was integrated into the Command Information Display System at CP Tango and also into the closed circuit television system at the Hardened Air Tactical Command and Control Center at Osan Air Base. Those interfaces allowed the CINC videoconferences to be transmitted to almost all members of the combined battle staff at both locations. The TVSS cascades across four multipoint control units (MCUs) which gives the ability to switch between more videoconferencing sites. The system can also operate at four different rates: T-1, 512 kbps, 384 kbps, and 128 kbps. (ISMA, 1993, p.1)

The ability to perform rate changes was put to the test when the USS Blue Ridge, which was afloat and operating at 384 kbps, communicated across two multipoint control units to the Army operations center at the Pentagon. Admiral Wright on the Blue Ridge and Admiral Tuttle at the Pentagon conducted a forty minute videoconference which demonstrates the capabilities of the system. (ISMA, 1993, p.2)

Another benefit of tactical videoconferencing during this exercise was the ability of the staffs to plan operations from different locations. TVSS was credited with saving the air planers up to 10 hours a day in planning the air campaign which gave the executors of the air campaign more time to devote to mission preparedness. This is an important factor when one considers that in joint/coalition campaigns, such as Desert Storm, the bulk of the air power came from geographically dispersed assets. The TVSS allows the staff officer to hear the CINC's guidance directly from the commander with no filtering or time delay which allows extra time for planning and execution. (ISMA, 1993, p.2)

B. VIDEOMEDICINE

Videomedicine is simply the practice of medicine when the patient and the provider are separated by distance so that connectivity between the two is provided by electronically supported medium. Videoconferencing allows the medical profession to extend the practice of medicine to areas were it may not be available. The benefits of videomedicine are just beginning to be explored and the only limit to its use is the imagination of the user. The patients benefit by having timely access to medical specialists that may not be available to isolated locations. Videomedicine also avoids long and costly air evacuation of the patient by providing a panel of medical experts to review all patients whether the patients are soldiers on the battlefield or civilians during emergency relief. (LeBlanc, 1993, pp.1-17)

1. Remote Health Care Providers

Currently Trippler Army Medical Center (TAMC) in Hawaii is the leader within the Army in the area of videomedicine. The use of videomedicine allows Trippler Army Medical Center to provide medical consulting and remote care to all of the Pacific area of operations. Videomedicine not only benefits the patients in remote regions but also the Trippler Army Medical Center itself. Trippler Army Medical Center is able to extend medical services to distant beneficiaries, provide the ability to learn about various tropical diseases, select patients for training programs, and improve the ability of Trippler Army Medical Center to conduct air evacuation and preparation of incoming patients. (LeBlanc, 1993, pp.1-17)

2. Telemedicine Capabilities

The hospital at Trippler has a Compression Labs Rembrandt II system that operates from 56 kbps to 1.544 mbps. The medical center also has a mobile medical monitoring vehicle that has a Compression Labs Eclipse videoconferencing system that is capable of linking back to Trippler Army Medical Center by tactical satellite or by landline circuit.

Although the vehicle is not a combat ready vehicle, it is a system that could be located at a field hospital or in an emergency relief area. The vehicle allows Trippler Army Medical Center to focus a medical presence within and outside the hospital. The vehicle is also a link between field troops and the medical center. The use of videomedicine on the battlefield could provide the greatest benefits to the Army and the medical community. By installing videoconferencing systems at field hospitals, a panel of doctors could evaluate the wounded and then route them within the medical system to provide the best care for the wounded soldier. (LeBlanc, 1993, pp.1-17)

3. Tactical Videomedicine

In an exercise conducted at Ft. Gordon during June 1993, the Army tested the capabilities of videomedicine in a warlike environment. The exercise, known as the advanced war fighter demonstration, tested the Army's Global Grid which uses commercial technologies as a backbone for worldwide military communications. A mobile army surgical hospital, outside Ft. Gordon, Georgia, was operated by a team of medical specialists from the 18th Field Hospital located at Ft. Bragg, North Carolina. The hospital site had a video link and access to medical data to provide medical support on a level equal to that of many top ranked hospital complexes. These medical specialists were able to perform surgical procedures using advising surgical specialists located at Walter Reed Army Medical Center in Washington, D.C., and the University of Virginia Medical Hospital in Charlottesville, Virginia.

Remote cameras provided live videos of simulated wounded. Doctors at each location used work stations to view the medical files, vital signs, video and CAT (Computerized Axial Tomography) scan imagery from medical facilities nationwide. Each computerized display was divided into four quadrants, with information and imagery displayed simultaneously during surgery. After the exercise, senior Army medical personnel offered that the availability of this technology might have saved as many as 30 percent of the personnel who died in Vietnam.(Ackerman, 1994, p.29)

4. Future Videomedicine Advancements

Currently the Army and DOD are very interested in the possibilities that videomedicine can provide. With the success that has been shown at Trippler Army Medical Center the DOD plans to expand its videomedicine services to Special Forces/ Civic Action Teams, U.S. Navy ships, and other medical centers within the U.S. military. Within the Pacific basin, Trippler Army Medical Center currently has remote videomedicine sites in Japan, Korea, and Kwajalein. Trippler Army Medical Center plans to extend to more remote sites such as the Marshall Islands, Hawaiian Islands Outlying Areas, and U.S. embassies in the region. Future upgrades also include 24 hour service, multimedia desktop computer systems, and more full motion video systems that can be deployed to a tactical and garrison environment. (LeBlanc, 1993, pp.1-17)

C. VIDEOTRAINING AND DISTANCE LEARNING

Videotraining is the fastest growing use of videoconferencing within the Army today. Videotraining is defined as the integration of digitized video, audio, and data with state-of-the-art telecommunications technology into a videoconferencing system that can more effectively provide training for target populations. The objective of a videotraining system is to provide and improve the distribution of training to selected target populations. The training occurs at specific times, in specified locations, and under a variety of environmental conditions. Until recently, resident training within the Army has depended on personal delivery by an instructor using the traditional classroom lecture. Through the medium of videoconferencing, simulated face-to-face training can be delivered to troops, units, and activities in the field.(VTT, 1993, pp.1-2)

1. Current Videotraining Capabilities

Videotraining is currently conducted over two nets, TNET, Video Teletraining Network, and SEN, Satellite Education Network, that are managed by TRADOC. Because the individual nets will be discussed later in this thesis, this section will concentrate on videotraining capabilities. Currently, videotraining users consist of the Defense Language Institute, TRADOC service schools such as Transportation, Armor, Military Police, and Field Artillery, and Special Forces units. Video training increases the training opportunities in a number of ways. These include permitting personnel to get training that would be otherwise unavailable, reducing the backlog of training requirements, and allowing units to solve maintenance problems faster and better than with manuals alone. Units that have videotraining capabilities do not have to worry about getting allocations to send personnel away for training. This allows updated methods to get to the user quicker and a larger number of personnel can receive training at one time. Also, training can be conducted during tactical field exercises and combat to allow immediate feedback on fielding of new equipment or proper usage of current equipment. Videotraining allows a unit to provide training to remote sites where it is difficult and costly to rotate personnel or send instructors. (Laws, 1992, pp. 17-18)

2. Video Teletraining Network (TNET)

The video teletraining network is the largest fully interactive videotraining network in the world. The system is managed by the U.S. Army Training Support Center at Ft. Eustis, Virginia. The system provides two-way video, two-way audio, and multipoint videoconferencing transmitted over a SBS-5 satellite owned by Hughes Network Systems that covers the entire continental United States. The SBS-5 can transmit interactive training to as many as eight remote sites in a single class session where students can see and hear instructors and other students. Currently the TNET consists of 50 sites and is continually growing in hopes of being expanded to overseas garrison locations. At the present time the system is capable of supporting overseas locations only in a combat situation.(Laws, 1992, pp. 17-18)

3. Satellite Education Network (SEN)

Although the Satellite Education Network has less capabilities than the TNET, it is a larger network. The Satellite Education Network is managed by TRADOC at Ft. Lee, Virginia. The system has four studios and 101 down-link locations. The system is limited in that it provides only one-way video and two-way audio over satellite links. The system concentrates mainly on the instruction of logistics and acquisition subjects. The SEN system was used extensively during Desert Shield/Storm to provide language training to soldiers located in both the combat zone and the United States. TRADOC also conducted logistics after action reports with units that had deployed to the combat zone using this system. These were then recorded and broadcast to units deploying to the Persian Gulf region in order to prepare the units for logistics problems. (Welles, 1993, pp. 9-12)

V. VIDEOCONFERENCING ARCHITECTURE IN SUPPORT OF A CORPS/DIVISION AREA

A. CORPS OVERVIEW

The corps consists of a headquarters which plans, directs, controls, and coordinates the corps operations and a mix of combat, combat support, and combat service support units which are employed by the corps commander to accomplish its missions. Appendix E provides an organizational diagram of a corps and division. An organizational chart of a typical corps is shown in Appendix E, Figure E-1. Corps are tailored for the theater and the mission for which they are deployed. For this reason, the standard organizational structure of a corps is rather flexible. A corps is composed of three to five divisions (peacetime versus wartime). An Army is composed of three to five corps. Further discussion of an Army's composition is not germane to this thesis, therefore it will remain focused on the corps and division level. (FM 100-15, 1989, pp.21-24)

A corps area of operation is approximately 37,500 square kilometers (the size of Rhode Island plus) and consists of about 75,000 troops. Because a corps is a large element covering a large geographic area, command and control cells are located at the Corps Rear or COSCOM, the Corps Tactical Command Post (TAC) and the Corps Main Command Post to help the corps fight and support the divisions. The following sections will provide an overview as to how videoconferencing can be implemented in a corps area to provide better command and control for the commander, better staff support for higher and lower echelon units, and integrate videotraining and videomedicine in support of combat operations.(FM 100-15, 1989, pp.21-24)

1. Corps Rear

The corps rear command post provides management to the corps administrative and support units which is the lifeline of the corps and the divisions. The rear operations commander is normally the deputy corps commander, and he is responsible for the command and control of the planning and the execution of the corps rear operations. (FM 100-15, 1989, pp.47-411)

a. Rear Command Post Structure

The corps rear command post is divided into three cells. The cells are the headquarters cell, the operations cell, and the combat service support (CSS) cell. The headquarters cell consists of the rear operations commander, the operations cell consists of a representative from the G1, G2, G3, G4, Aviation, ADA (air defense artillery), Chemical, Engineer, FSE (fire support element), MP (Military Police), and Signal. The CSS cell consists of representatives from G1, G4, G5, AG (Adjutant General), Chaplain, IG (*Inspector* General), MP, PAO (Public Affairs Officer), SJA (Staff Judge

Advocate), and Surgeon. The corps level field hospital is usually located in the corps rear area. (FM 100-15, 1989, pp.47-411)

b. Videoconferencing Support For Corps Rear

The corps rear is a fixed location that does not move very often thus the corps rear is the best location for the multipoint control units (MCUs) which control all the videoconferencing in the corps and divisions. The equipment needed at the corps rear would be a mid-size or large roll-away system such as the Compression Labs Radiance or the Rembrandt, a MCU, and a conference room to conduct videoconferencing. For this system the communications link to other elements in the net would be a TSC-85[*] satellite system. This system can run a videoconference at bandwidth rates of 56 kbps to 1.024 Mbps. The TSC-85 is located at the corps rear in the current communications architecture, so this setup would not require any equipment to be moved from other locations to support videoconferencing. The corps videoconferencing coordinator should be a signal corps officer located at the corps rear and his duties would be to coordinate all multipoint and point-to-point videoconferences.

A videoconferencing system at the corps rear can be used for several purposes. The primary purpose is staff

[*] The TSC-85 satellite system is a 24 channel system that is configured to operate as a hub in a tactical communications net.

planning that reduces time and travel that is normally associated with all planning between the corps rear and the divisions. The corps rear staff is responsible for the administrative, logistics, and maintenance support for the corps. In this capacity, the staff members spend a great deal of time with the corps main command post developing the plans for future combat operations. Once the plans are completed, the corps rear staff then must coordinate with the divisions to provide the necessary support to accomplish the corps mission. With a videoconferencing system, the corps G3 at the corps main, the corps G4 at the corps rear, and all division G3 and G4 personnel can conduct a videoconference to discuss all tactical and logistical shortcomings. This meeting can be conducted without any personnel travel required. Additionally, a videoconferencing system at the corps rear would be the primary entry point into a tactical unit for videotraining. The corps staff section that best represents the topic of training would be responsible for arranging whom should be involved in the videotraining. This would also allow quality control to be exercised over any videotraining to ensure that the time is being well spent.

2. Tactical Command Post

a. Tactical Command Post Make-up

The tactical command post (TAC) concentrates on the current battle that the corps is conducting. The tactical command post is small and mobile because detailed planning is conducted at the main command post. The tactical command post is designed to operate in a mounted configuration, but could be dismounted if conditions allow. The organization of the TAC is simpler and more flexible than the main. It is organized into a single cell and is under the control of the G3. (FM 100-15, 1989, pp.47-411)

b. Videoconferencing Support for the TAC

In order to maintain the flexibility and mobility of the TAC, it is recommended that no videoconferencing equipment be located at the TAC. However, the relationship between the corps commander and the TAC may dictate that the TAC have videoconferencing equipment for use in planning with the corps main and also with the division operation cells. If videoconferencing equipment is installed, it is recommended that a small roll-away system such as the Compression Labs Eclipse system be used. The TSC-93[9] satellite system can be used to provide the communications link to the MCU at the corps rear. The TSC-93 is located at the TAC in the current communications architecture, so no equipment reconfiguration would be required.

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[9] The TSC-93 satellite system is a 12 channel system that is configured to operate as a spoke in a tactical communications net.

3. Main Command Post

The main command post synchronizes the command and control system, providing continuity for the corps operations. The corps main is where the corps commander is located and the corps plans all future operations. The corps main is more future oriented than the TAC. The corps main is the primary planning location for all combat, combat support, and combat service support operations within the corps. (FM 100-15, 1989, pp.47-411)

a. Main Command Post Structure

The main command post is divided into six cells. The cells are the headquarters cell, the plans cell, the current operations cell, the fire support cell, the intelligence cell, and the combat service support (CSS) cell. The headquarters cell consists of the corps commander, the chief of staff, and the command liaison personnel. The plans cell and the current operations cell consists of a representative from the G3, G2, G4, G1, G5, FSE, Chemical, ADA, Engineer, Aviation, MP, and Signal. The fire support, CSS, and intelligence cells are specialized cells that consist of specialist in the area of fire support, CSS, and intelligence. (FM 100-15, 1989, pp.47-411)

b. Videoconferencing Support For The Corps Main CP

The primary function of a videoconferencing system at the corps main would be command and control for the commander, and staff planning. The best videoconferencing system to perform this type of videoconferencing would be a mid-sized or large roll-away system such as the Compression Labs Rembrandt or the Radiance system. The recommendation of this thesis would be a Rembrandt system with dual 35 inch monitors to provide the best possible resolution for the commander. Depending on the importance of the videoconference, the resolution could be determined by the corps commander. For example, if the videoconference is with the Chairman of the JCS or the CINC, the corps commander could chose a higher bandwidth to provide the best videoconferencing resolution. The Rembrandt system has multipoint capabilities which would allow the corps commander the ability to videoconference with higher and lower echelon units simultaneously. The videoconferencing system can operate at bandwidth rates that range from 112 kbps to 1.544 mbps. The ability to operate at a wide range of bandwidths is required for videoconferencing with echelons above corps (EAC) units such as a JTF or Army level unit. The Rembrandt system is compatible with almost all videoconferencing systems on the market since it contains a digital and analog output which allows it to be directly routed into a PICTEL or VTT system. (CLI, 1993, pp.1-4)

The communications link for this system would be a TSC-85 satellite system. Three TSC-85's are located at the corps main command post in the current communications architecture so no equipment reconfiguration would be required.

B. DIVISION OVERVIEW

1. Division Structure

A division is composed of four line brigades (three land and one air), a Division Support Command (DISCOM, Brigade size), a Division Artillery (DIVARTY, Brigade size),and several separate battalions (Military Intelligence, Military Police, Air Defence Artillery, Signal Corps, Engineers, etc.). A division has roughly 15,500 troops. An organizational chart of a typical division is shown in Appendix E, Figure 3. The division command structure is the division rear, division main and the tactical command post (TAC). The division commander is located at the division main while the assistant division commander maneuver (ADC-M) is at the TAC and the assistant division commander support (ADC-S) is at the division rear. (FM 100-15, 1989, pp.21-24)

The division conducts the same operations as the corps but on a smaller scale. For this reason, the functions of the division main, division rear, and division TAC will not be discussed since the are the same as those performed at the corps level. The personnel at each location in the division mirrors those at the corps. The only point is that different divisions are tailored for specialized missions which result in minor changes in the structure. These differences will not affect the primary need and location of videoconferencing systems within the division. (FM 100-15, 1989, pp.21-24)

2. Division Videoconferencing Architecture

The division videoconferencing system would need to provide command and control, staff support, videotraining, and videomedicine support for all units in the division. This can best be accomplished by establishing two videoconferencing centers within the division. The primary videoconferencing facilities should be located at the division main and the division rear.

a. Division Main Videoconferencing

The videoconferencing facility at the division main would serve primarily in a command and control and staff support role. The division commander would reap a large benefit in the area of time management and command and control with a videoconferencing site at the division main. The division is continually having to meet with the corps commander and the division commanders of adjacent divisions. A videoconferencing system would allow him to update the corps commander face-to-face on a daily basis without leaving the division main. The division commander could conduct command and control meetings with the division rear which would allow division rear and division main personnel to receive command guidance directly from the commander without filtering from other staff sections.

The division main plans all future operations which requires a large amount of planning with the corps staff and possibly with the staffs of adjacent divisions. The staff at the division main also does a large amount of staff planning with the division rear. With videoconferencing facilities at both locations this would the reduce the movement of personnel during combat operations. The equipment that would best serve the division main would be a small roll-away system such as the Compression Labs Eclipse. The Eclipse should operate at 128 kbps when videoconferencing with division rear and operate at 328 kbps or higher when working with corps or another division. The communications link would require the videoconferencing system to connect with the MCU at the corps rear. This communication link can be provided by the TSC-85 that is located at the division main which would require no changes to the current communications configuration. For point to point videoconferencing with the division rear the communications link could use the existing Mobile Subscriber Equipment (MSE) system or the satellite link between division main and division rear without going through the corps system.

b. Division Rear Videoconferencing

The videoconferencing facility at the division rear would serve primarily in a support role. Its functions would include videotraining, videomedicine, and staff support. The division rear would be the best location to conduct videotraining because representatives from all units are located there and could coordinate use of a videoconferencing room for videotraining. Most of the breakthrough trends that would need to be immediately sent out to the force would be technically related and would most likely concern maintenance, supply, signal, or some of the other combat support and combat service support units at the division rear.

As for videomedicine, the field hospital to support the division is located at the division rear. This is also the most important point in the medical evacuation chain of command since this is the point where wounded first see a doctor in a hospital. At this point the seriously wounded could be evaluated by a staff of doctors using videomedicine and routed to the hospital in the theater to best provide support to the wounded.

The staff support provided by videoconferencing would allow the division rear staff to coordinate face-to-face with the division main and the corps rear without lost time for travel. The equipment that would best serve the division rear would be a medium roll-away system such as the Compression Labs Radiance. The Radiance should operate at 128 kbps when videoconferencing with division main and operate at 328 kbps or higher when working with corps or another division. The communications link would require the videoconferencing system to connect with the MCU at the corps rear. This communication link can be provided by the TSC-93 that is located at the division rear which would require no changes to the current communications configuration. For point-to-point videoconferencing with the division main the communications link could use the existing MSE system or the satellite link between division main and division rear without going through the corps system. A signal officer at the division rear should be designated as the videoconferencing officer to provide management and troubleshooting capabilities for the division.

C. CORPS/DIVISION VIDEOCONFERENCING SYSTEM USAGE

The corps/division videoconferencing architecture outlined would allow a large group of diverse users the opportunity to access videoconferencing assets from anywhere in the world. The staff of the corp and division could perform staff planning with other corps, divisions, and staffs located thousands of miles away. The corps operations personnel could perform face-to-face battle rehearsals with the division and CINC staffs without any travel required. In some cases, a videoconferencing system provides command and control and staff planning. This is the case with any use by the corps or division commander. The commander decides whom he wishes to include in a videoconference and then gives out guidance on a specific mission. By including subordinate commanders and staff as well as his own staff, the commander is also able to get instant feedback and recommendations from all personnel.

The commander can also receive backbriefs from all subordinate commanders without any of his key leaders leaving their primary duty location. This is key during combat operations when travel between division and corps may be impossible.

The medical personnel at the corps and division hospital could receive routing instructions on seriously wounded personnel from medical teams in CONUS locations. This would allow CONUS medical staffs to better prepare for the type of incoming wounded. Videotraining centers could also be established at the corps and division rear to allow breakthrough trends to be immediately be transmitted to the units on the battlefield.

VI. CONCLUSION

The intent of this thesis was to examine the current and future uses of videoconferencing in both a tactical and garrison environment within the Army. In order to properly conduct this thesis, background research of video compression, videoconferencing equipment, standards, and transmission medium was completed. Chapter II, Appendix A, and Appendix B provided the reader with an overview of the technical characteristics of a videoconferencing system. This allows the reader to become familiar with the terms that become the backbone of videoconferencing discussions.

After the technical characteristics of a videoconferencing system are discussed, the thesis examines the role videoconferencing plays in the Army. The current status of videoconferencing is changing and growing quickly in the Army. Commanders and staff personnel are discovering that time and money can be saved by embracing videoconferencing systems that are in place at most Army installations within the U.S. and Korea. Interoperability issues are a small problem now but will continue to grow due to the lack of clear standards within the Department of Defense and the civilian contractors of videoconferencing equipment. The Army commander is the key to solving this problem by ensuring that standards are developed and that future equipment purchases are compatible with existing systems.

Current videoconferencing systems were examined and classified as small, midsized, and full room systems. The capabilities and size of the systems were discussed with specific model types introduced to the reader. The tactical and garrison requirements were discussed with the dual purpose systems being introduced. Dual purpose systems are systems that can operate in both a garrison and tactical environment. These systems are key to videoconferencing being fully embraced by the commander. The commander has little need for a system that can operate in a garrison environment only. The Army Vision states that future systems must operate in both garrison and tactical environments in order to reach the full potential that the videoconferencing systems can provide. Bandwidth, survivability, and system security requirements are examined in both environments. The examination reveals that there is no need to separate the systems. A videoconferencing system can be purchased off the shelf from commercial vendors that can perform in both environments.

The Army is presently using videoconferencing in three major roles including staff planning, videomedicine, and videotraining. Tactical examples of all three uses were discussed with the technical and communications requirements discussed for the staff planning exercise. These areas are where the growth and money are being focused within the Army.

One area that is not being exploited is the use of videoconferencing systems as command and control tools for the commander at division and above. The main reason for this is, as stated above, the commander currently has no videoconferencing system that he can use in a garrison environment and then deploy to a tactical environment. Most divisions have a videoconferencing site (Appendix C) that consists of a large room and a mounted videoconferencing system. All future videoconferencing systems should be roll-away models that can be deployed anywhere the division goes. This type of system would also allow the unit to take advantage of the other videoconferencing uses. The unit could continue to participate in videotraining which allows key personnel to remain current on breakthrough trends and receive critical training before or during combat preparations.

Videomedicine systems may prove to be the most important systems because of the many lives that can be saved using this technology. The battlefield that soldiers are required to fight on is more lethal than ever. Because of this fact, wounded soldiers must be diagnosed as quickly as possible and routed to the hospital that can best suit the needs of the wounded. The tactical exercise that was conducted at Ft. Gordon proved extremely successful in the area of videomedicine. More research is needed in this area and all Army commanders should push to get videomedicine to the battlefield as soon as possible.

The final topic discussed was the implementation of a videoconferencing system at the corps/division level. The location and type of videoconferencing systems within a corps and a division were defined. The type of communication systems used to inter-connect the videoconferencing systems of the corps and division are also discussed. The relationships between the users are introduced, but these could change when an actual system is installed in a tactical environment. It is difficult to estimate the actual usage of a system. The current relationships of staff sections and the usage logs of garrison videoconferencing systems were used to estimate the amount of usage that might occur in a tactical environment. It is the opinion of the author that videoconferencing usage would increase on garrison systems if a tactical system was put into use because more operations personnel would use videoconferencing as a replacement for face-to-face meetings that are difficult or impossible in tactical conditions.

Face-to-face meetings can not be replaced by the telephone alone. Breakthroughs in videoconferencing technology will allow the Army to continue to conduct simulated face-to-face meetings without leaving the primary location on the battlefield and in garrison. The time is now to take advantage of videoconferencing technology and develop a working and practical videoconferencing system for both garrison and tactical environments. The benefits of this system will continue to grow as users become more comfortable working in this electronic environment.

APPENDIX A. VIDEO TRANSMISSION PRIMER

This primer is designed to provide a short what and why about video transmission. Video transmission is complex and must deal with four factors when transmitting images of moving objects. (Jolley, 1992, p.100)

1. A perception of the distribution of luminance or simply the distribution of light and shade.
2. A perception of depth or a three-dimensional perspective.
3. A perception of motion relating to the first two factors.
4. A perception of color (hues and tints). (Freeman, 1991, p.866)

The first factor that a video transmission systems must deal with when transmitting a subject is luminance (the lightness and darkness of the image). A moving object must be interpreted in terms of height, width, depth, and time. To accomplish this, a video scanner views each frame of the moving image as shown in Figure 1. (Freeman, 1991, pp.866-867)

This scanning is done from left to right one pixel (a horizontal strip of discrete square elements) at a time. The luminance value of each pixel is translated into a current or voltage level and transmitted over the video transmission system. (Freeman, 1991, pp.866-867)

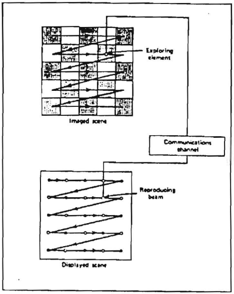

Figure 1 Video Image Scanning
(Freemen, 1991, p.867)

The National Television Systems Committee (NTSC) standard for television image resolution is 525 horizontal scanning lines. These scanning lines determine the resolution of the picture. The higher the number of scanning lines the sharper the image of the video.(Freeman, 1991, p. 867)

The aspect ratio (width-to-height ratio) of a video image is 4:3. Therefore, a video image that has a vertical height of 525 lines will have a horizontal width of 700 lines.[10] (Freeman, 1991, p. 867)

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[10] 525 horizontal scanning lines that are stacked on top of each other produces a vertical height of 525 lines. 700 vertical scanning lines that are placed from left to right gives a horizontal width of 700 lines.

The amount of vertical detail that can be reproduced is 64 to 87 percent of the active scanning lines. Therefore a video transmission system must be capable of transmitting the translated luminance of approximately 224,264 (491 vertical pixels x 525 horizontal pixels x .87) pixels for each individual frame of a moving image. This scanning process occurs continuously during transmission and takes only a few microseconds to perform. (Freeman, 1991, p.867)

APPENDIX B. T1 NETWORKING PRIMER

T1 and the expanded system of carriers refer to a general system of facilities (see Table I), a Digital Signal Designation (DS), and various framing conventions. The DS is a bit rate for a particular T carrier. The voice-digitization rate (VDR) scheme that serves as the backbone for the entire series of Digital Signal Designations is 64 kbps or DS0. (Black, 1989, pp. 723-724) T1 refers to any digital transmission facility capable of transmitting 24 voice grade channels (equivalent of 24 DS0) at the rate of 1.544 mbps (DS1). Currently T1 facilities are able to support a mix of audio, video and data channels. (Black, 1989, p.723)

In addition to the ability to transmit various communication media, another advantage of the digital T1 facilities is the ability to use a variety of transmission media. These media include:

1. Twisted-pair wires that were a part of the original T1 facilities.
2. Microwave relay facilities that require a line of sight transmission path and a Federal Communications Commission (FCC) license.
3. Infrared relay facilities that also require a line of sight path but do not require a license.
4. Optical fiber that only requires repeaters every 100 miles and is virtually immune to noise effects.

5. Coax cable that requires repeaters every 40 miles. (Black, 1989, pp.117-139, 724)

The flexibility of the T1 facilities in terms of communications and transmission media makes the system favorable to many of the Army's needs. It is believed that the technology of the T carriers will eventually evolve into FT3 and T4M to accommodate requirements for more bandwidth. (Black, 1989, p.724)

TABLE I AT&T DIGITAL FACILITIES

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

(Black, 1989, p.724)

APPENDIX C. DCTN VIDEOCONFERENCING SITES

The following is a list of Army installations that currently have videoconferencing sites. All of the sites are large videoconferencing rooms that are equipped with a variety of videoconferencing equipment. There are three communities of interest in the Army. These consist of Headquarters Department of the Army (HQDA)/ TRADOC, Forces Command (FORSCOM), and Army Material Command (AMC).

HQDA/TRADOC.

1. Carlisle Barracks, PA.
2. DISA HQ, VA.
3. Ft. Ben Harrison, IN.
4. Ft. Benning, GA.
5. Ft. Bliss, TX.
6. Ft. Chaffee, AR.
7. Ft. Eustis, VA.
8. Ft. Gordon, GA.
9. Ft. Huachuca, AZ.
10. Ft. Jackson, SC.
11. Ft. Knox, KY.
12. Ft. Leavenworth, KS.
13. Ft. Lee, VA.
14. Ft. Leonardwood, MO.
15. Ft. McClellan, AL.
16. Ft. McPherson, GA.
17. Ft. Monroe, VA.
18. Ft. Rucker, AL.
19. Ft. Sam Houston, TX.
20. Ft. Shafter, HI.
21. Ft. Sill, OK.
22. Pentagon (HQDA), VA.
23. Trippler AMC, HI.

FORSCOM

1. DTS-Pentagon,VA.
2. Ft. Bragg, NC.
3. Ft. Campbell, KY.
4. Ft. Carson, CO.
5. Ft. Drum, NY.
6. Ft. Gillem, GA.
7. Ft. Hood, TX.
8. Ft. Irwin, CA.
9. Ft. Lewis, WA.
10. Ft. Meade, MD.
11. Ft. Polk, LA.
12. Ft. Riley, KS.
13. Ft. Stewart,GA.
14. Presidio of San Francisco, CA.

AMC

1. Aberdeen, MD.
2. Adelphi, MD.
3. Alexandria, VA.
4. Chambersburg, PA.
5. Ft. Belvoir,VA.
6. Ft. Monmouth, NJ.
7. Huntsville, AL.
8. Natick RDEC, MA.
9. OUSDA Pentagon, VA.
10. Picatinny ARS, NJ.
11. Rock Island, IL.
12. St.Louis, MO.
13. Warren, MI.
14. White Sands, NM.
15. CAP, Alexandria, VA.

APPENDIX D. TACCIMS VIDEO SUPPORT SYSTEM (TVSS)

Theater Automated Command and Control Information Management System (TACCIMS) has added a new capability for coalition command and control. Videoconferencing is proving to be a superb adjunct to the CINC's C^3 capability of leading the units assigned to his command.

TVSS is a secure bilingual videoconferencing system that links in real time the CINC with his component and field commanders. TVSS was successfully integrated into the Combined Forces Command in Korea to include the Crisis and Wartime headquarters, subordinate command headquarters, alternate command posts, and a U.S. Navy Command and Control ship. TVSS is secured with U.S. CRYPTO equipment (KG-81 or KG-94). At the present time there are no releasable equivalents for the Republic of Korea.(Brundage, 1993, p.1)

The videoconferencing system that is used in TVSS is the Rembrandt II system produced by Compression Labs Inc, and the Korean vendor for CLI is Samsung. The CLI Multipoint ontrol Unit or MCU is used for multipoint videoconferencing. These systems conform to CLI's proprietary algorithmic standard for a MCU and not a commercial or military standard. This is an important point when the interoperability of a network is considered. For instance, a PICTEL system cannot connect directly to the MCU in the TVSS. This problem was solved by taking the analog output of the PICTEL system and imputing that into a CLI system to permit interface to the MCU. This technique was successfully used during exercise ULCHI FOCUS LENS 92 (August 92). The current system operates at a system link speed of T-1 (1.544 mbps) and is capable of operating at speeds from 56 kbps to 1.544 mbps. The preferred speed is 1.544 mbps or 512 kbps. These speeds allow for optimum resolution and ease of use.(Brundage, 1993, p. 2)

One of the unique features of the system is the capability for dual language audio. The system is a commercial product and one of its limitations is that it only digitizes one input audio source for in-band transmission. In the combined/coalition environment that the Army operates in, the Army must provide a dual audio capability to simultaneously transmit English and another language, in this case Korean. The limitation of the commercial system does not obstruct the ability to achieve this goal. First, the primary audio is applied to the audio input port of the system. Then the secondary audio feed is passed through a voice digitizer. Finally, the digitized audio signal is routed into a data port on the system for transmission in-band with the digitized video and primary audio. This capability is currently operating within the TVSS system in Korea. At the distant sites the binational target audience hears the audio over two mediums. The majority language group for the site will have the audio played over speakers in the room. The minority language group will have the audio pass over an Infrared (IR) transmitter to IR receiver headsets. The use of IR headsets is a very inexpensive solution that accommodates almost every site layout without the need for hardwiring the sites. This increases the flexibility of the audience arrangement and composition. (Brundage, 1993, p. 3)

TVSS also has the capability to send and receive still frame graphics. Most often the still frame graphic images are briefing charts for display to the CINC. However, the graphics capability is only limited by the user's imagination. The TVSS system can also be wired into an existing closed circuit television system which allows for a videoconference to be viewed throughout a headquarters if this is desired by the CINC. (Brundage, 1993, p. 3)

Naturally, TVSS is highly dependent on communications connectivity. The system uses leased and Defense Communications System (DCS) circuits, and on a limited basis tactical satellite communications. The communications capacity and capabilities will be expanded to increase the use of tactical satellite, tactical line-of-sight, and the Defense Switching Network (DSN). This will give the CINCs the ability to hold videoconferencing in both a tactical and garrison environment while maintaining a survivable system. TVSS takes command and control one step further. Most of the automated C^3 systems are information disseminators, while videoconferencing gives the CINCs interpersonal command relationships that are so vital to commanders.(Brundage, 1993, p. 4)

APPENDIX E. CORPS/DIVISION ORGANIZATION

Appendix E provides a graphical overview of the organization of a corps and a division. Appendix E also includes a reference page of the symbols that are included in the corps division organizational chart and a diagram of the corps communication system and the bandwidth associated with each link. Figure 2 is an organizational chart of a typical corps. Figure 3 is an organizational chart of a typical division. Figure 4, 5, and 6 are reference pages of the symbols that are found on the organizational charts of the corps and division. Figure 7 is a SATCOM (satellite communications) system of a typical corps.

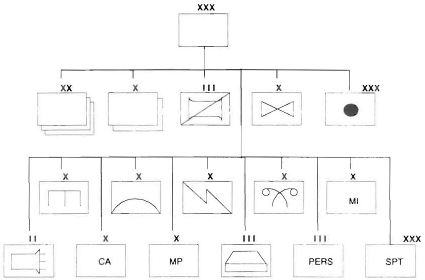


Figure 2 Corps Organizational Chart (FM 100-15, 1989, p.2-3)

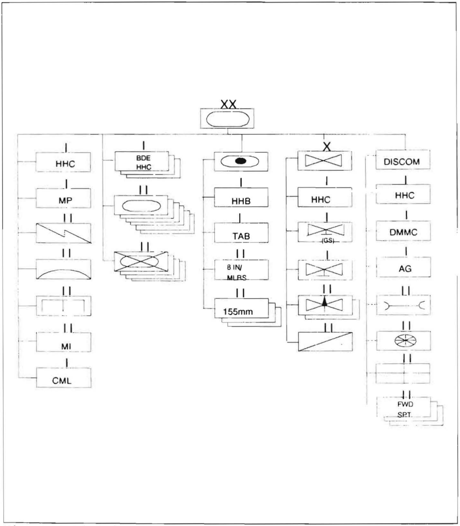


Figure 3 Division Organizational Chart(FM 24-1, 1985, p.1-7)

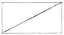
SYMBOL	DESCRIPTION	ABBREVIATION
○○	Section or Squad	SEC, SQD
○○○	Platton or Detachment	PLT, DET
I	Company, Battery or Troop	CO, BAT, TRP
II	Battalion or Squadron	BN, SQDRN
III	Group or Regiment	GRP, REG
X	Brigade or Equivalant	BDE
XX	Division	DIV
XXX	Corps	CRP
	Infantry	INF
	Armor	AR
	Recon or Cavalry	RECON, CAV
	Engineer	ENG
	Artillery	ARTY

Figure 4 Organizational Chart Symbol Reference Page (FM 101-5, 1985, pp.25-218)

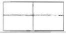
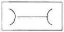
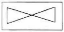
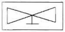
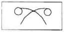
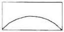
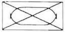
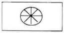
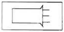
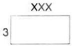
SYMBOL	DESCRIPTION	ABBREVIATION
	Medical	MED
	Maintenance	MNT
	Aviation	AV
	Avaition (Rotary)	
	Attack Helicopter	
	NBC	NBC
	Air Defense Artillery	ADA
	Mechanized Infantry	MECH INF
	Armored Recon (CAV)	ARC
	Armored Artillery (Self Propelled)	AARTY (SP)
	Signal/Commo	SIG
	Transportation	TRANS
	Psychological Operations	PSYOPS

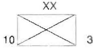
Figure 5 Organizational Chart Symbol Reference Page (FM 101-5, 1985, pp.25-218)

SYMBOL	DESCRIPTION	ABBREVIATION
CA	Civilian Affairs	CA
PERS	Personnel	PERS
	Finance	
AG	Adjutant General	AG

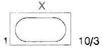
EXAMPLES :



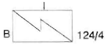
: III Corps



: 10th Infantry Division, III Corps



: 1st Brigade (Armor), 10th Inf Div, III Corps



: B Comapany, 124th Sig Bn, 4th Div

Figure 6 Organizational Chart Symbol Reference Page (FM 101-5, 1985, pp.25-218)

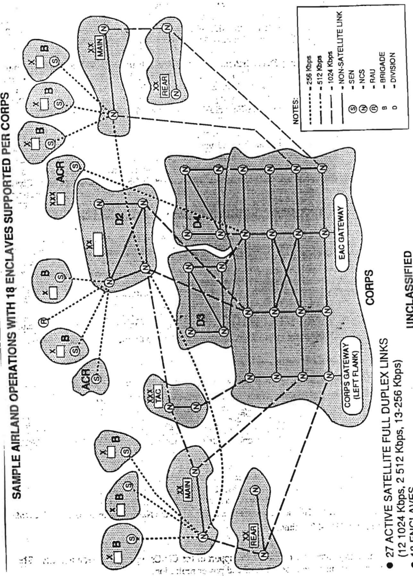


Figure 7 Corps SATCOM Communications

LIST OF REFERENCES

1. Ackerman, Robert K., Army Doctors Experiment With Long Distance Video Surgery, *Signal*, February 1994, p. 29.

2. Army Enterprise Strategy, The Vision, Headquarters, Department of the Army, Washington, D.C., January 1993, p. 21.

3. Barezzane, M., Compression Codes for Contribution Applications, *Electronic Communications*, 3rd Quarter 1993, p. 220-226.

4. Bellato, L., The Fundamentals of Video Transmission, *Electronic Communication,*3rd Quarter 1993, p. 214-219.

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

6. Brundage, John., TACCIMS Information Booklet, DISA, 1993, pp.1-4.

7. Cole, Bernard, The Technology Framework, *IEEE Spectrum,* March 1992, p. 32-39.

8. Compression Labs Inc, CLI Rembrandt System, CLI Brochure pp. 1-4, 1993.

9. Compression Labs Inc, CLI Eclipse System, CLI Brochure pp. 1-4, 1993.

10. Compression Labs Inc, CLI Radiance System, CLI News Release, p.1, 1993.

11. DISA, Defense Switched Network Overview, Defense Information Systems Agency, p.41, 1994.

12. Economist, The Future of Medicine: A Survey of Future Medicine, *Economist*, March 1994, pp. 4-17.

13. Flanagan, Patrick, Videoconferencing: A Status Report, *Telecommunications*, April 1993, p. 41-48.

14. FM 101-5, Combat Operations, Headquarters, Department of the Army, Washington, D.C., January 1993.

15. FM 100-15, Corps Operations, Headquarters, Department of the Army, Washington, D.C., September 1989.

16. FM 24-1, Combat Communications, Headquarters, Department of the Army, Washington, D.C., September 1985.

17. FM 101-5-1, Operational Terms and Symbols, Headquarters, Department of the Army, Washington, D.C., October 1985.

18. Freeman, Roger L., *Telecommunications Transmission Handbook*, 3rd ed., p.867, John Wiley & Sons, Inc., 1981.

19. Fujiwara, Hirosi, An All-ASIC Implementation of Low Bit-Rate Video Code, *IEEE Transactions on Circuits and Systems for Video Technology,* Vol. 2, No. 2, June 1992, p.123-133.

20. Huhn, Norbert, Applying Videoconferencing, *Telecommunications,* August 1992, p.27-30.

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

22. ISMA, TACCIMS , ISMA Product Release, September 1993, pp.1-2.

23. Jurgen, Ronald, Digital Video, *IEEE Spectrum,* March 1992, p. 24-30.

24. Jolly, Martin E., *Video Teleconferencing Feasibility Study at the Naval Postgraduate School*, Master's Thesis, Naval Postgraduate School, Monterey, California, 1992.

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

26. Laws, Alice, Video Teletraining, *Army Trainer*, Fall 1992, pp. 16-18.

27. LeBlanc, John, Videomedicine Briefing to the Surgeon General of the Army, Trippler Army Medical Center, October 1993, pp.1-17.

28. McDonald,Fred L., Mitre Report, Videoconferencing Systems Interconnections Options, pp.1-3, September 1993.

29. McCleary, Bob, FORSCOM Report, FORSCOM Videoconferencing Logs, March 1994, pp.1-17.

30. Pancha, Pramod and EL Zarki,Magelu, Bandwidth *Allocation* Schemes for Variable-Bit-Rate MPEG Sources in ATM Networks,*IEEE Transactions on Circuits and systems for Video Technology,* Vol. 3, No. 3, June 1993, p. 190-198.

31. Schweber, William, Electronic Communications Systems, pp. 430-434, Prentice-Hall, 1991.

32. Stallings, William, *ISDN: An Introduction*, pp. 224-246, MacMillan Publishing Co., 1989.

33. Sullivan, Robert, Compression Labs, Incorporated, p.1, Paine Webber, Incorporated, 1990.

34. Telephone conversation between Bob McCleary, FORSCOM, and Cpt. William Churchwell, 08 March 1994.

35. Welles, Alison, Teaching the Troops: The U.S. Army Has Taken Training to the Airwaves, *Teleconference,* March 1993, pp.9-12.

36. Zenisek, Tom, Videoconferencing over the Public Network, *Telecommunications*, December 1992, p. 19-22.

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