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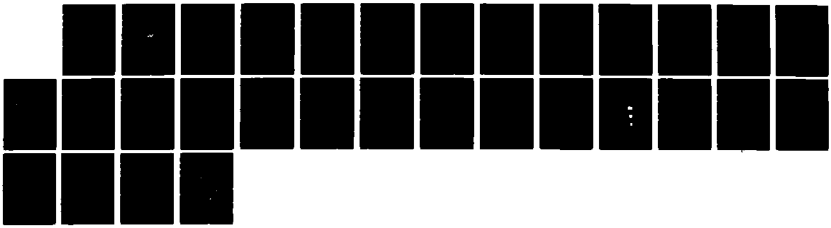

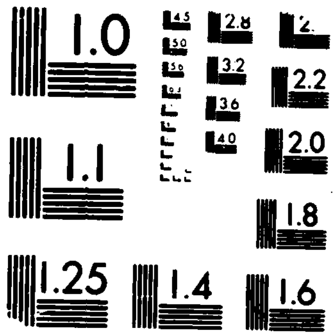


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Final Technical Report
SAIC-87/1900

# Enhancement of the Shared Graphics Workspace

Prepared by
Frances M. Clements

Science Applications International Corporation

December 31, 1987

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SAIC-87/1900

# Enhancement of the Shared Graphics Workspace


Prepared by
Frances M. Clements

Principal Investigator
Kevin F. Vest

Science Applications International Corporation
CSM Division
1300 Wilson Boulevard, Suite 100
Arlington, Virginia 2220


Prepared for
Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, VA 22209

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This final report discusses work done by CSM Division of Science Applications International Corporation to enhance the U.S. Air Force/Foreign Technology Division (AF/FTD) video-teleconferencing system (VTS). It covers upgrade of the UNIX 6.0 operating system to ULTRIX-11; installation of high-density, 70 megabyte disk drives; upgrade of serial communication; installation of Datacopy cameras and Apple Laserwriters; and installation of two additional nodes to the original VTS.

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## CONTENTS

## LIST OF FIGURES

# SUMMARY

CSM Division of Science Applications International Corporation (SAIC) has enhanced the Shared Graphics Workspace (SGWS) used in the two-node Video-Teleconferencing System (VTS) developed by CSM Division for the U.S. Air Force/Foreign Technology Division (AF/FTD). CSM Division has also installed two additional nodes, at Vought Corporation, in Grand Prairie, Texas, and at Lockheed Corporation, in Mountain View, California. A major enhancement was installation of ULTRIX-11 to replace the UNIX 6.0 operating system. The new operating system increases reliability and flexibility of the SGWS, and it is portable. Other enhancements include installation of high-density 70-megabyte unformatted disk drives; upgrade of serial communications on the PDP 11/23s to DPV11 interface; installation of a Datacopy digital camera to speed digitization, display, and transmission of hardcopy documents, and installation of Apple LaserWriters to improve the production of hardcopy.

## 1.0 INTRODUCTION

Since 1980, CSM Division of Science Applications International Corporation (SAIC) has been researching and developing video-teleconferencing systems (VTS) for the Defense Advanced Research Projects Agency (DARPA). Under Contract MDA903-84-C-0008, with Defense Supply Service--Washington, CSM designed, developed, and installed, under DARPA auspices, a two-node VTS that connects the Air Force Foreign Technology Division (AF/FTD), in Dayton, Ohio, with an intelligence-production facility on the East Coast.

In April 1985, CSM transferred this system to the Air Force. It transmitted black-and-white images via the Compression Labs, Inc. (CLI), 19.2-Kbps (kilobits per second) Sketch Coders; used TSP-2000 voice codecs for audio; and allowed teleconference participants to share and annotate information via the Shared Graphics Workspace (SGWS) image transmission feature. The development of this system is detailed in the Technical Report CSMI/TR-85/01: *Transfers and Enhancements of the Teleconferencing System and Support of the Special Operations Planning Aids*, October 31, 1985.

On 28 September 1985, Modification P0007 to Contract MDA903-84 C-0008 directed CSM Division to enhance the hardware and software in the SGWS and to expand the VTS to four nodes by installing additional nodes at Vought Corporation, in Grand Prairie, Texas, and Lockheed Corporation, in Mountain View, California.

This final technical report details CSM Division's work to enhance the SGWS and expand the VTS to four nodes. Section 2.0 gives background on the development of the SGWS and the rationale for the enhancements. Section 3.0 discusses the project objectives, and Section 4.0 addresses in detail work done to meet these objectives. Section 5.0 gives a conclusion.

Additional information appears in the Interim Technical Report, CSMI/TR-86/03, *Enhancement of The Shared Graphics Workspace*, submitted to the Defense Advanced Research Projects Agency on May 1, 1986.

## 2.0 BACKGROUND

The version of the SGWS that was transferred to the AF/FTD in 1985 consisted of a red-green-blue (RGB) monitor, with a touchscreen; a menu box; a videodisc player; data communications interfaces; a sync generator; a graphics processor; a DEC PDP11/23 computer; and a facsimile machine. It allowed teleconference participants to share videodisc images and computer graphics displayed in color and text and facsimile information displayed in black on amber. They could annotate the information in up to five colors and print the annotated version at both sites, using a standard fax machine. The SGWS also used a fax machine to digitize the image, which could be stored in a computer database for recall upon demand.

Once the initial two-node system was installed, users found that they often needed to send documents or black and white photographs for discussion during a teleconference. Documents in machine-readable form; that is, those created via the screen editor on the SGWS or transferred via magnetic media presented no transmission problems. However, hardcopy documents had to be printed via a special facsimile interface. This cumbersome process required two minutes per page to digitize the document, eight minutes per page to distribute it to the other sites, and four minutes per page to locally decompress the image. Because of this slow processing time, documentary information could not be shared at adhoc meetings; nor could late-arriving material be conveniently added for discussion during a conference.

## 3.0 OBJECTIVES

The enhancements incorporated in the SGWS under Modification P0007 aim chiefly at speeding up the processing and transmitting of hardcopy documents and improving the resolution of the images. To these ends, CSM Division replaced the facsimile machines with digital cameras, installed laser printers, upgraded the serial communications on the PDP11/23s, and developed and installed software to support these hardware upgrades. Figure 1 shows the upgraded SGWS configuration. In addition, in place of the UNIX Version 6.0 operating system originally installed on the system's PDP11/23s, CSM installed the ULTRIX operating system with Berkeley 2.9BSD enhancements and modified existing SGWS software to operate under ULTRIX. Finally, to facilitate the development process, we installed high-density 70 megabyte (unformatted) disk drives with tape backup on the development systems.

Once these upgrades to the AF/FTD SGWS were completed, CSM Division installed upgraded VTS nodes at two additional sites, thus completing a four-node system (Figure 2). Besides the enhanced SGWS, these nodes include the CLI Sketch Coders and TSP voice codecs. Unforseen delays prevented the Air Force from providing communications for the VTS; for this reason complete testing of the additional nodes has not been possible.

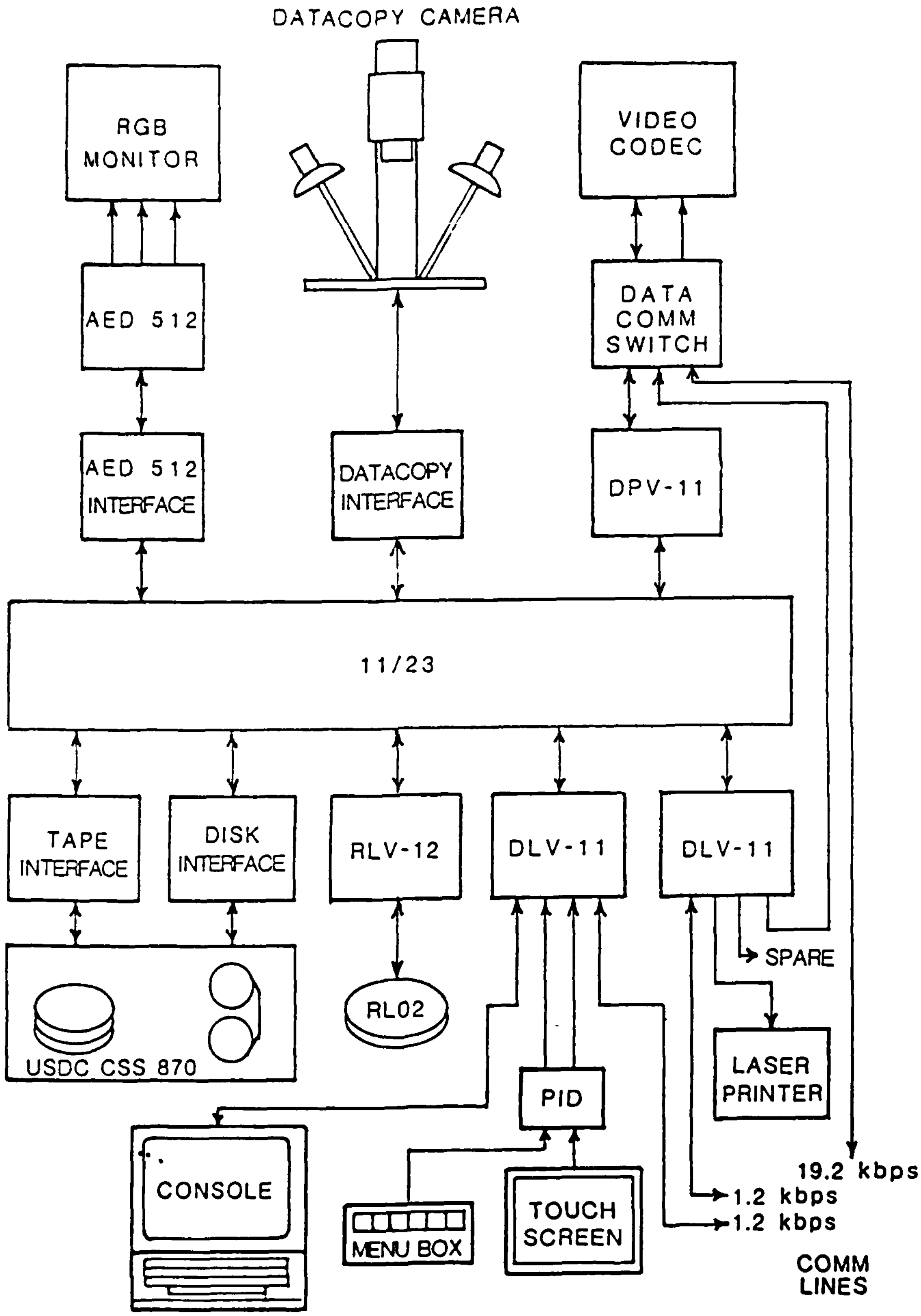
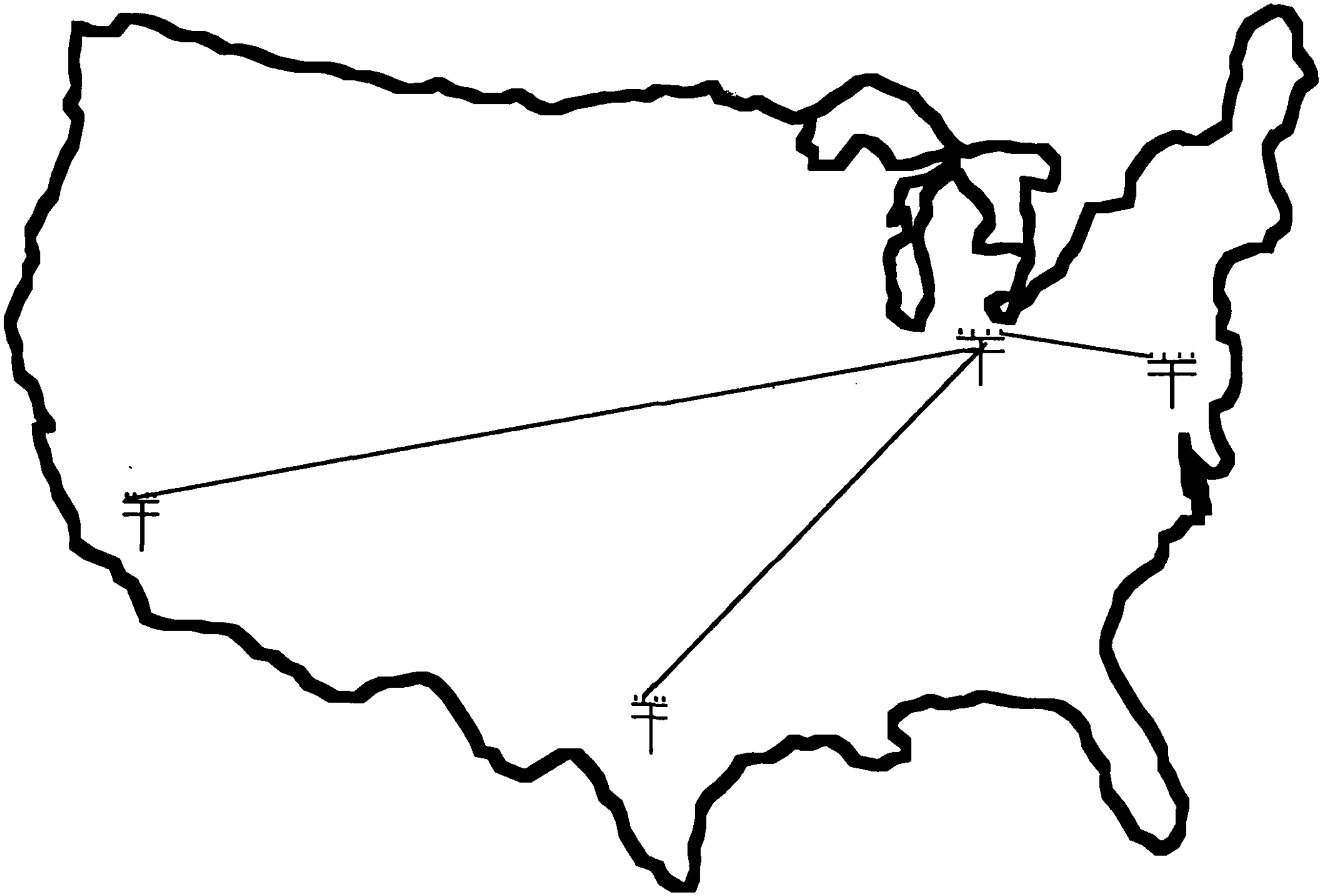



Figure 1
SGWS Configuration



**4 Node** **Dedicated Land Lines**

**Figure 2**
**AF/FTD-VTS Locations**

## 4.0 TECHNICAL APPROACH

This section details the steps CSM Division of SAIC took to design, develop, and install hardware and software enhancements to the Shared Graphics Workspace (SGWS) and to install additional nodes at Vought Corporation, in Grand Prairie, Texas, and Lockheed Corporation, in Mountain View, California.

### 4.1 Installation of the Ultrix Operating System.

A major task under Modification P0007 is to install the ULTRIX operating system with Berkeley 2.9 BSD enhancements on the PDP 11/23s used in the SGWS. Originally, the SGWS was developed with UNIX 6.0. A powerful software research tool, 6.0 was the only version of UNIX that would run on the 11/23 at that time. Moreover, because the staff at CSM Division, where the SGWS was developed, had extensive experience with UNIX 6.0, they were always available to maintain the file-system integrity and solve operating-system problems; and the UNIX system at CSM was compatible with the version of UNIX then used at the East Coast facility. Finally, at the time, no industry-wide UNIX standard had been clearly defined.

Despite these advantages, UNIX 6.0 proved to suffer from several difficulties: First, it has a fragile file structure that requires extensive system-programmer support for repairs. This is not a great problem in the development laboratory, with expert technical staff on site; it becomes a problem, however, under operational conditions at widely separated sites, where staff lack needed expertise. A further problem is that no one now provides vendor support for UNIX 6.0. In addition, though UNIX is a programmer-friendly system, UNIX 6.0 has few standard user-friendly applications.

Recently, UNIX System V and Berkeley UNIX have become the industry standards as well as the accepted test-bed for defense-related research projects. Though these reasons alone would justify the upgrade of the AF/FTD operating-system software to one of these standards, these systems also offer other advantages: Most important, they have the reliability to perform effectively under heavy use. In addition, they are portable, a feature that permits rapid transfer to a large audience of potential users; and they have the flexibility to adapt rapidly to the ever-changing needs of the defense community. Since System V is not available for the PDP 11/23, ULTRIX-11, a variation of the UNIX Version 7, with Digital Equipment Corporation (DEC) enhancements, was chosen for the upgrade. It offers the added advantages of DEC support for DEC equipment and of the latest University of California Berkeley enhancements.

### 4.2 Installation of High Density 70 Megabyte (unformatted) Disk Drives with Tape Backup.

Modification P0007 required that CSM Division also install 70 megabyte, unformatted disk drives with tape backup. To do this required modifying the ULTRIX-11 tape and disk drivers to make them compatible with the U.S. Design Corporation (USDC) CS800 tape and disk drives. The tape driver presented no problem, but the disk driver proved recalcitrant for several reasons:

- The USDC drive is not totally compatible with the DEC RK07 disk drive that it emulates.
- The USDC drive performs Drive Reset functions more slowly than the DEC RK07 does.
- Since source code was not available for the ULTRIX-11 disk driver, programmers had to hand-patch compiled code.
- Source code for other systems, such as BSD 2.9 or V6, was not helpful, because DEC has extensive error logging and bad track management, features that cause difficulty for the USDC disk drive.

After strenuous efforts, CSM programmers abandoned attempts to patch the ULTRIX-11 RK07 driver. Many of the RK07's features, like error logging and disk interleaving, are not appropriate for the USDC drives, even if they could be made to work. Therefore, the CSM programmers wrote, installed, and debugged a driver especially designed for the USDC CS800 disk drive.

### 4.3 Upgrade of Serial Communications.

Modification P0007 originally required upgrading of the serial communications on the PDP 11/23s to DHV11s. However, on January 17, 1986, because of a decision to use a synchronous protocol, which does not require start and stop bits for each byte of information, rather than an asynchronous one, representatives of CSM Division and FTD agreed to use instead the DPV11 interface. It transmits larger amounts of data than does the DHV11, and it has a built-in CRC error detection for more trouble-free transmission. Because no driver for the DPV11 is available under ULTRIX-11, CSM Division programming staff ported the driver developed under UNIX Version 6.0 to ULTRIX-11. Doing this required a substantial rewrite of the driver.

Implementing a functioning high-speed driver was difficult for several reasons. The PDP 11/23 processor is slow, and the ULTRIX-11 operating system runs more slowly than those of earlier, less complex UNIX implementations. In addition, because data is sent at 19.2 kilobits per second (Kbps) and because we have assumed noisy communications lines and designed a system capable of dealing with them, handshaking becomes especially important.

The DPV11 driver runs a bit-oriented synchronous data link control (SDLC) protocol. It recognizes cyclic-redundancy-check (CRC) and byte-count errors but has no time to deal with error handling when data is being transmitted at 19.2 Kbps; therefore, CSM Division programmers have written calling applications to perform this function: to send data to and receive it from the DPV11 driver and to take care of basic handshaking and of error detection and correction. The timing of these actions provides intervals during which other operations can take place; therefore, they must be precisely tuned to ensure proper handshaking between the two computers.

The DPV11 driver is PIO (programmed input/output) driven rather than interrupt driven. An interrupt-driven version of this driver was written but abandoned when it lost data. The loss occurred because of the long time needed for the 11/23 to vector to and from an interrupt service routine while higher priority interrupts and non-interruptable processes contended for processor time. If the PIO mode is to work, the priority level of the driver has to be set so high that all interrupts are locked out, including the time-of-day clock. As a result, the clock stops during a file transfer; and when it resumes operation, it is off by several seconds, the exact number depending on the size of the file transferred.

File-transfer applications were written to interact with the DPV11 driver. These applications send data to and receive it from the DPV11 driver, verify good or bad reception, and take care of basic handshaking. The timing of these actions provides a window during which system actions can take place. This means that very precise timing and delays tuned to the type of processor must be used to ensure proper handshaking of the two machines. This process does ensure, however, that unless the communications lines are severely degraded, the data will be processed correctly.

### 4.4. Installation of Digital Cameras.

The facsimile machines in the original SGWS required two minutes to digitize each page, eight minutes to distribute it to the remote site, and four minutes to decompress the image. To speed up this cumbersome process and improve the resolution of scanned images, CSM Division replaced the facsimile machines with Datacopy cameras (Figure 3). CSM programmers developed the driver that

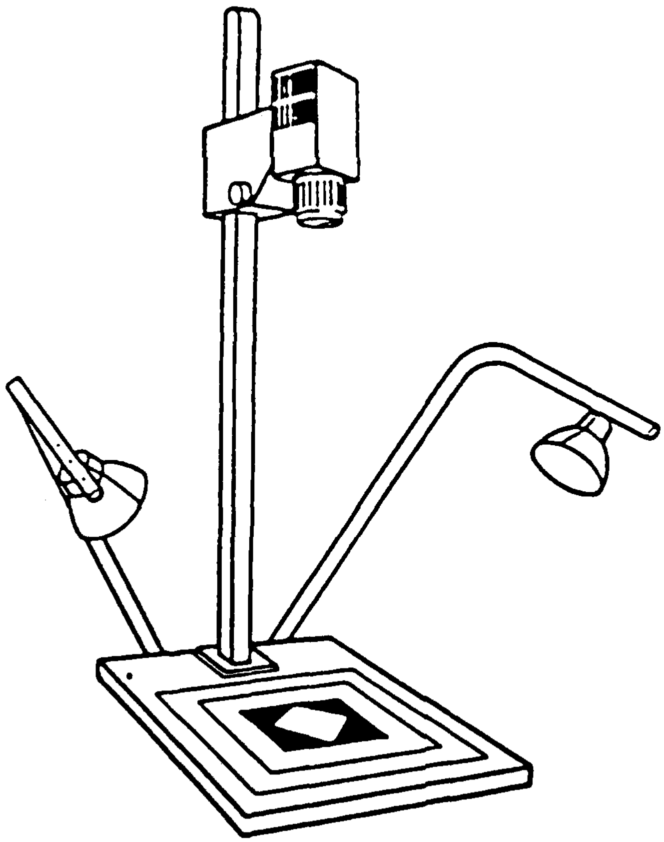


**Figure 3**
**Datacopy Camera**

controls the operation of the Datacopy camera and wrote application programs that tell the driver at what level of magnification to scan a document.

For the system to display a document, whether text or photo, the camera scans the document, digitizes the data, and sends it via direct memory access (DMA) to the computer, which in turn DMAs it to the Advanced Electronics Design (AED) graphics processor. Black-and-white photos appear in 16 shades of gray, with a resolution of 512 x 512 pixels. The AED automatically displays the image on the RGB monitor of the SGWS.

Originally, CSM programmers developed a system that took approximately 10 seconds to scan and display a photo. However, the AED allows the use of only eight bit planes; and all eight were used to transmit the image, leaving none to use in annotating it. To solve this problem, CSM staff devised a program to eliminate half of the scanned data and thus leave four bit planes to use for annotations. Which half of the data gets thrown away depends on how light or dark the user chooses to make the image. The process of eliminating the unwanted data adds to the time needed to scan and display a photo. In addition, integration of the system into the SGWS means less available buffer space for the DMA from the camera, thus slowing the process even further.

Division staff developed a driver for the Datacopy camera so that the "open," "read," "close," " and "I/O control" ("stty" and "sgtty") calls on the camera would work under ULTRIX, just as they would for a standard UNIX device.

Tests of the driver led to some changes. One change directs the driver to warn an application program whenever the program tries to communicate with the camera and fails--usually because the camera is turned off, disconnected, or busy. Should this warning not be given, the application could send further commands that would hang up the system. Another change rearranges the sequence of camera activities in scanning a printed text or photo. Formerly, when the system commanded the camera to scan, a two- or three-second pause ensued, while the camera moved to the start position at the top of the document; then the lights came on, and the camera began to scan. As modified, the camera moves to the top of the document as soon as the application program attempts to communicate with it, without waiting for the command to scan, and moves there again after each scan. As a result, immediately after the scan command is given, the lights come on and the camera scans the document. This re-arrangement moves the mildly annoying two- to three-second pause to a place in the process where the user does not notice it.

Once the camera driver was developed, programming work shifted to writing applications that use the camera. One CSM Division routine directs the camera to scan an area equal to 1/16 of the display area on the SGWS pod monitor and send the scanned data to memory via direct memory access (DMA). Because of limited space for DMA, the camera must scan a photo in segments. The application then writes the data to disk and directs the camera to repeat the process 15 times on the remaining areas of the photo until enough data is available to fill the screen of the pod monitor. The entire process takes only 25 to 30 seconds.

Other software work included new utilities written to test various options with both the document and the photographic modes of SGWS. For scanning photographs, we developed a mode that allows the option of full eight-bit gray scale and a zoom mode on three levels: 512 x 512, 1,024 x 1,024, and 1,536 x 1,536 pixels.

To improve the photographic mode of the Shared *Graphics* Workspace (SGWS), programming staff added a software-controlled zoom feature that compensates for the limited size of the image display imposed by the copystand. A 1:2 zoom gives a 7" x 7" display; a 1:3 zoom a 10.5 x 10.5 display. The larger bitmaps have 2 x 2 and 3 x 3 pixel cells averaged with luminance mapping. The following table gives digitization-and-display times. (These are compared in graphic format in Figure 4.):

| Zoom | 11/73 | 11/23 |
|---|---|---|
| 1:1 | 20 seconds | 32 seconds |
| 1:2 | 31 seconds | 1:16 minutes |
| 1:3 | 44 seconds | 1:55 minutes |

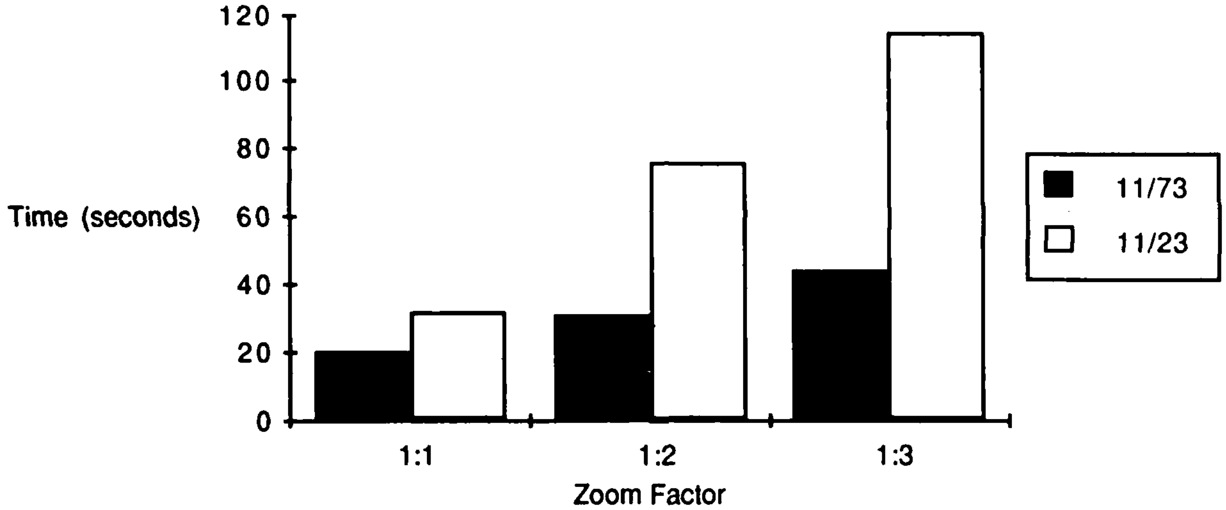



**Figure 4**
**Digitization and Display Times**

The quality of the digitized images is very good, even for textual material. However, because the current hardcopy with halftoning makes the text hard to read, we have developed an algorithm that does not use halftoning.

The quality of displayed photographs was vastly improved by user-adjustable mapping for contrast and brightness levels. By adjusting the contrast level, a user can scan photographs through a range of contrasts from full 16-level grey scale, useful for detailed pictures, to 2-level grey scale, for pages of text.

Creation of new files from data digitized by the Datacopy camera gave rise to a vexing problem: users could unthinkingly give a new file the same name as that of an existing file. This action wiped out the earlier data. A routine written by the CSM Division programming staff checks the file names and when it finds a duplication offers users the option of choosing a new name or overwriting the existing file.

## 4.5 Installation of Laser Printers

To improve the printing capability of the SGWS, CSM acquired two Apple LaserWriters. Each consists of a Laser printer with its own internal 68000 processor and 768K of memory; and each is controlled by the PostScript language, from Adobe Systems. This printer can accept RS-232 data at speeds up to 9.6 kbps with XON-XOFF handshaking. In addition, it has an RS-422 port that can accept data at up to 288 kbps. The LaserWriter can print graphical, half-toned, and gray-scale data as well as standard text.

To print hardcopies on the SGWS, CSM Division programmers wrote three PostScript programs: a program to print Tektronix-compatible graphics, another to print scanned pictures, and a third to print ASCII text files by emulating a Diablo printer. Though the Apple LaserWriter can emulate a Diablo printer in firmware, using this feature requires the user to get up and turn a knob that changes the mode on the LaserWriter. Because users find this distracting during a teleconference, CSM programmers have written a PostScript program that emulates the Diablo mode. To print a text file, the system sends the Diablo-emulator PostScript program and the text data; to print a Tektronix graphics file, it sends the Tektronix data and the PostScript program that decodes that data; and to print a scanned document or photograph, it sends another PostScript program and the compressed scanned data.

To print scanned photographs and documents on the LaserWriter, software developed by CSM Division staff converts the raw binary data to ASCII hexadecimal, and then sends a PostScript program that allows the LaserWriter to read the hexadecimal data and print the message in 9.5 minutes. By reducing the amount of scanned data by 50 percent, with no loss of picture quality, we have reduced printing time to just over 4 minutes. However, converting data to hexadecimal increases the time by one minute, for a total of 5 minutes to print scanned photographs and documents. But this time is not a problem for users because the pictures are spooled for later printing, after the conference ends.

All of these print routines issue requests via the UNIX system's "lp" program, which CSM Division staff have modified so that it sends the correct PostScript program for the data.

Once the CSM staff had developed the single, standalone PostScript programs for the LaserWriter, the next task was to modify the SGWS so it sends the proper PostScript program and data to the LaserWriter to print images, Tektronix graphic files or text files.

With the SGWS print function, users print computerized files or scanned materials, as well as the current briefing page; that is, the material and any user annotations shown on the monitor. To speed up the unduly slow Ultrix print process, CSM programmers wrote a faster print spooler to replace the inefficient Ultrix spooler. The Ultrix spooler reads the data, processes it, writes the processed data to disk, reads the data from disk, and finally sends it to the LaserWriter. The more efficient CSM spooler reads data, processes it, and sends it directly to the printer.

In addition, CSM programmers have rewritten spooling software to speed up the program, which was running too slowly. The program now uses part of the picture space as a print spooling area. At the end of an SGWS session, the spooling program is spawned, and the files in the spool area printed. Other improvements to the SGWS include modifying the spooler program so that it has software handshaking to the LaserWriter, a feature that dramatically improves the reliability of the spooling process.

Because Ultrix must give time to this additional process, the time it can devote to running the SGWS program decreases, thus slowing operation of the SGWS. To solve this problem, CSM programmers changed the priority level of the spooler; this means that the spooler runs more slowly and, as a result, the SGWS speeds up. Since users interact directly with the SGWS and only indirectly with the spooler, they notice only a slight slowdown in SGWS operations after they make a print request.

### 4.6 Installation of Additional Nodes

In September 1987, engineering and programming staffs at CSM Division installed two additional nodes for the AF/FTD. These upgraded systems link Vought Corporation, in Grand Prairie, Texas, and Lockheed Corporation, in Sunnyvale, California, with the two original sites, on the East Coast and in Dayton, Ohio. Once they completed the installation, Division staff tested both nodes in standalone mode and found them to work as they should. They could not test the system at either location in a two-node link because the communication lines were not ready.

## 5.0 CONCLUSION

The enhancements to the AF/FTD Video-Teleconferencing System have improved the system in several respects. The upgrade of the UNIX Version 6.0 operating system to ULTRIX-11 has meant a more reliable, user friendly system that does not require extensive system-programmer support. In addition, the installation of the Datacopy camera in place of the facsimile machine and the upgrade of serial communications to a DPV11 driver on the PDP 11/23s have increased the speed with which the VTS can transmit images of hardcopy text and photographs. The Datacopy camera has also greatly improved the resolution of images, and the addition of Apple LaserWriters has enhanced the quality of hardcopies. Finally, installing 70-megabyte, high-density disk drives with tape backup gives the system much needed storage space and backup capabilities.

In the rapidly changing video-teleconferencing field, however, technical breakthroughs occur almost daily. Several recent ones offer opportunities for even further enchancements to the AF/FTD VTS. For example, UNIX is now available for both the IBM PC/AT and the MicroVAX. The purchase and maintenance costs for both of these computers are dramatically lower than such costs for the PDP11/23; thus it is now feasible to transfer the AF/FTD VTS to one of these higher-performance computer systems. A further development is the current generation of 1280-by-1024-pixel graphics processors, which give higher-resolution displays and which the high resolution of the Datacopy camera could easily support. A third development is in data communications interfaces, now available with on-board processors or DMA (direct memory access) support; these could make the VTS usable at higher bandwidths than are now possible. Finally, color-video printers or direct interfaces to the laser printer offer even higher-performance printing than does the present laser-printer system.

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