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TECHNICAL REPORT

CSMI/TR-85/Ø1

TRANSFERS AND ENHANCEMENTS OF THE TELECONFERENCING SYSTEM AND SUPPORT OF THE SPECIAL OPERATIONS PLANNING AIDS

by

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OCTOBER 31, 1984

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This report discussed enhancements to the Shared Graphics WorkSpace (SGWS) that increase the system's effectiveness and simplify its use. It also describes techniques to insure communications security for the Teleconferencing System; transfer of a low-bandwidth Teleconferencing System linking Fort George C. Meade with Wright-Patterson Air Force Base; network design-and-cost studies for earth stations at Suitland, Maryland, and Pearl Harbor; and a recommendation to upgrade the operating system of the Demonstration and Development Facility (DDF).

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SUMMARY

Between October 1, 1983, and October 31, 1984, Computer System Management, Inc. (CSM) enhanced the Teleconferencing System's Shared Graphics Work Space (SGWS) with increased storage space, a geographical database, an electronic-facsimile capability, an automated-briefing feature, and an SGWS User's Manual, all designed to increase the system's effectiveness and simplify its use for teleconference participants with little knowledge of data processing. CSM has also integrated a Widegren Communications, Inc. 56 kbps coder-decoder (codec) into a two-node demonstration Teleconferencing System, developed methods of insuring communications security during system transfer to secure sites, and begun transfer of an initial low-bandwidth system linking Fort George G. Meade with Wright-Patterson Air Force Base. Network design-and-cost studies recommend purchase of two Vitalink 6.1-meter, five-watt earth stations, to be installed at Suitland, Maryland, and Pearl Harbor. And evaluation of the Demonstration and Development Facility (DDF) led CSM technical staff to recommend upgrading the DDF operating system from UNIX 6.Ø to UNIX System V, level 2.Ø.

1.0 INTRODUCTION

This Final Report covers work done by Computer Systems Management, Inc. (CSM) between October 1, 1983, and October 31, 1984, on three projects sponsored by the Defense Advanced Projects Agency (DARPA): the Teleconferencing System, the Satellite Feasibility Study, and the Special Operations Planning Aids (SOPA). Subjects discussed include enhancements to the Teleconferencing System and work done to insure communications security when the system is transferred to secure sites; results of design-and-cost studies for transfer of a system linking naval command centers in Suitland, Maryland, and Pearl Harbor; and CSM's on-going provision of computer and demonstration facilities and staff and software support for SOPA.

2.0 TELECONFERENCING

CSM's teleconferencing work began in 1980 as a project to design and implement an inexpensive, easy-to-operate electronic notepad that allowed the user to annotate in five colors, page forward, page back, erase, clear the page, store previously annotated material, and later retrieve it. From this developed a four-station network of notepads, called Telepads, that transmitted one user's notations to all the other screens in the network. The system transmitted information from station to station via standard telephone lines and modems.

Building on the Telepad network, CSM took the next step: to develop a full-fledged teleconferencing system, where in times of crisis participants separated by distance could share information as they would in a face-to-face meeting.

A novel feature of the DARPA/CSM Teleconferencing System is the concept of virtual space, which allows each participant to focus on the speaker; localizes the audio so that the speaker's voice is associated with his or her image; and conveys non-verbal communication signals, like facial expressions. All this is accomplished with a remarkably small 19.2 kilobits per second (kbps) data channel.

The system, as developed, allows information sharing in real time and real motion. This means that the computer system reproduces precisely the actions of one teleconference participant (real motion) and transmits this information to other participants at the same time as these actions occur (real time).

Information shared via Telepad was limited to simple hand-sketched charts and graphs. The next step, the Shared Graphics Work Space (SGWS), designed for a low-bandwidth, virtual-space system, allowed teleconference participants to share and annotate more complex material, such as computer graphics and text.

To further augment the capabilities of the Teleconferencing System, CSM has now modified it to improve performance and user interface and has developed methods of insuring communications security while transferring the system to secure sites. These enchancements are discussed below.

2.1 Enhancements to the Teleconferencing System

Work is progressing on an initial low-bandwidth teleconferencing connection between the National Security Agency (NSA) at Fort George G. Meade, in Maryland, and the U.S. Air Force/Foreign Technology Division (AF/FTD), at Wright-Patterson Air Force Base, in Dayton, Ohio.

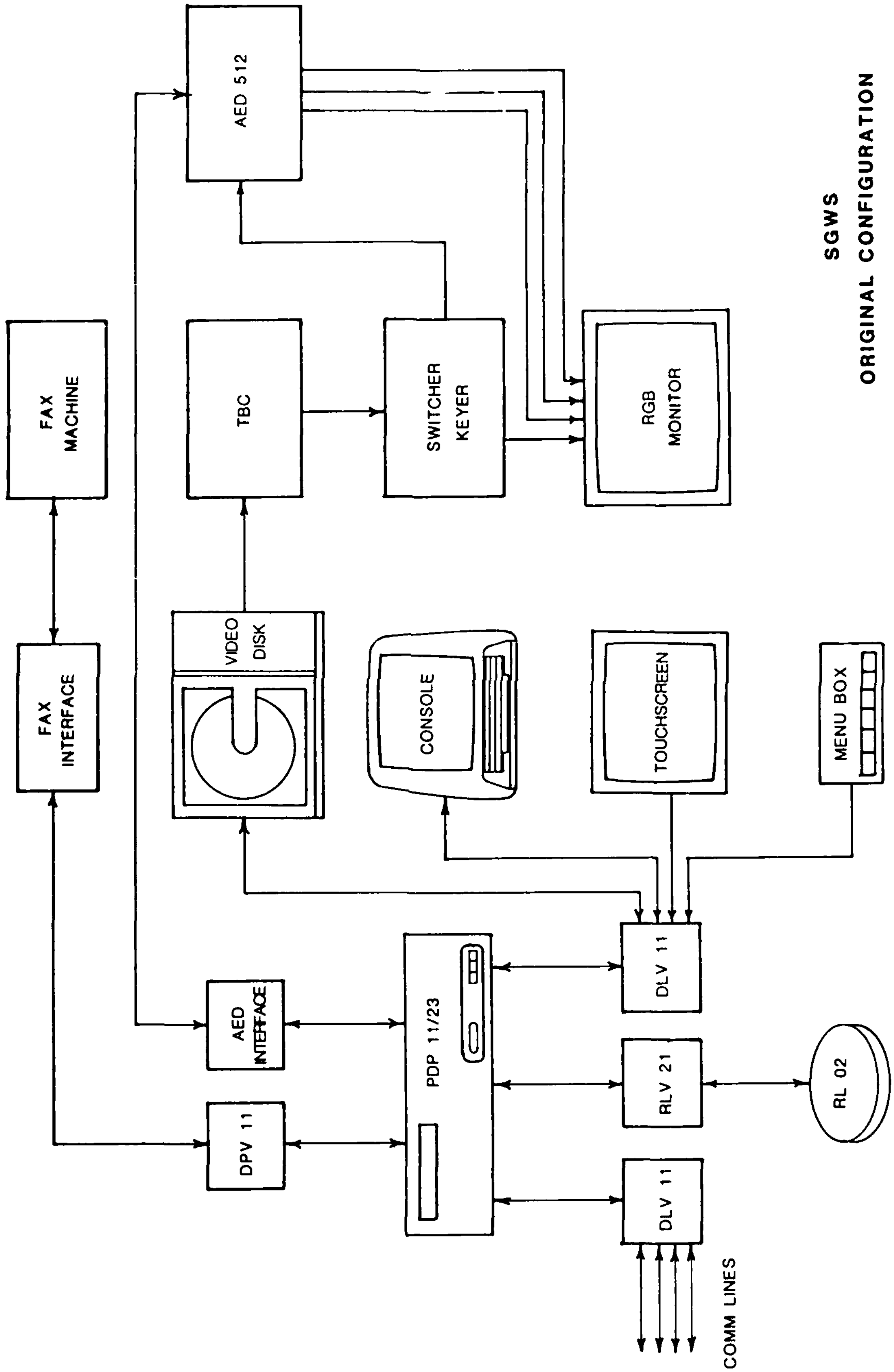
This Teleconferencing System consists of two video codecs and two microcomputers in a configuration that permits the participants to communicate as though face to face, sharing documents, and able to prepare and present briefings. Figure 1 shows how this system is configured.

As discussed in earlier reports to DARPA (cf. TR 83-Ø1, 83-Ø2, and 84-Ø1), the key function of teleconferencing is to provide the participants with an environment that, given the very low bandwith constraints, resembles as closely as possible a face-to-face meeting. The latest Teleconferencing System comes closest to reaching this goal. The NSA-AF/FTD Teleconferencing System has two components: the SGWS and the Compressed Bandwidth Codec (coder-decoder). These are discussed in the following sections.

2.1.1 The Shared Graphics Work Space (SGWS)

One of the original objectives of SGWS has not changed substantially since the beginning: to provide an electronic notebook that can be shared among several participants at a conference, when those participants are separated by distance.

FIGURE 1. Air Force Teleconferencing System



As SGWS has developed, CSM has augmented the notebook concept by increasing the storage space and adding a geographical database, an electronic-facsimile capability, and an automated-briefing capability. All of these facilities can be shared among all the participants of the teleconference. The Appendix lists equipment purchased to develop and enhance the SGWS.

2.1.1.1 Increased Storage Space

The original SGWS had only a limited amount of disk storage. To solve this problem, CSM added to the system a 70 megabyte Winchester disk drive, with a cartridge tape drive for offline storage, archives, and distribution of software. CSM also modified UNIX disk drivers to accomodate the new disk, thus increasing the size of the SGWS shared notebook from 20 to 132 pages. The increased speed and large cache memory of the Winchester drive allows the SGWS software to run much faster when doing file access or direct memory access (DMA) than it formerly did.

With the built-in tape drive on the Winchester, system archives are easier to create and maintain. The earlier method required removing the RL02 disk pack, transferring it to the Digital Equipment Corporation (DEC) PDP 11/70 computer, and then copying the disk pack to tape.

2.1.1.2 The Geographical Database

To increase the usefulness of the SGWS, CSM used video-disk technology that allows the system to store up to 54,000 pictures. Implementation of this feature required several steps: First, a video disk was made, which contains 3,000 pictures of Soviet ships and airplanes and 30,000 maps that show any area of the world in five or more levels of detail, from small to very large scale. Since each location is shown at different levels of detail by several different frames, users can zoom in or out of a location. The largest scale video frame, for example, might show all of Asia; successive frames then zoom in on smaller and smaller areas of Asia, finally pinpointing a particular location, like Kathmandu, Nepal.

Video disks are referenced via frame number. For example, frame 2385 might show a map of the area around Kathmandu. When the system was first developed, a master list gave the latitude and longitude covered by each frame, but did not list the names of places included on a particular frame. Thus, users had to know the geographical coordinates of Kathmandu before they could call up and view a map of that city.

To solve this problem, CSM adapted a geographical database containing 10,000 names of major cities around the world, along with their latitudes and longitudes. A formula was then developed that converts the latitude and longitude of a particular place, like Kathmundu, to the number of a video-disk frame showing the Kathmandu area at the level of detail specified by the user. The next step was to program an interface that allows a user to type in the name of Kathmandu or any other city and then instructs the computer to look up that city's latitude and longitude, change these to a frame number, and display that frame on all user's monitors.

To summarize, participants can obtain access to the geographical database, which the computer then searches, using location names as keys to the maps participants want displayed. A participant selects the menu option for access to the geographical database and types the name of the location to be displayed. All participants' monitors then display that section of the map.

2.1.1.3 Electronic Facsimile

Another element of the SGWS now being transferred to NSA-AF/FTD is an electronic-facsimile capability. Conventional facsimile transmission involves sending the image of a document from one facsmile (fax) machine to another. The SGWS, however, uses a fax machine to digitize the image.

After SGWS has digitized the image, the participants in a teleconference can store it in a computer database for recall upon demand; annotate the image during a teleconference; and print the annotated version at all participants' sites, using a standard fax machine.

To give the SGWS this ability, CSM had to adapt commercial fax machines and then custom design software and hardware devices to integrate into the SGWS.

Fax machines are built to communicate with each other. They go through a complicated "handshaking" procedure before they will send data to or receive it from another fax machine. Briefly, this handshaking consists of one machine's telling another that it wants to send a document. The receiving machine tells the sending machine that it is willing to listen. The sending machine responds that it is about to send, waits for a reply, and then sends the document. After the document is sent, both machines decide whether the transmission was successful.

In the SGWS the computer must emulate the role of either the sending or the receiving machine, depending on the user's command. A great deal of CSM time and talent was spent in developing software that makes the computer talk to a fax machine and makes the fax machine think that it is talking to another fax machine.

Once the computer began talking to the fax machine, it had to understand the data that the fax machine sent. To reduce the amount of information transmitted, fax machines use Huffman-coded data compression and decompression in hardware. The SGWS, however, must decompress each document in order to display it on the color monitor. Since the resolution of a fax machine is three times finer than that of the SGWS display device, the document has to be reduced in resolution by a factor of three. Tests showed that eliminating two out of every three pixels did not produce an acceptably clear picture. So the program analyzes the data to reduce the resolution and still keep as much information content as possible.

Once the document is displayed, users can annotate over it and print out the document with its annotations. The process requires the computer to read the annotations from the display device and then increase them by a factor of three. Next, the computer decompresses the original document, merges it with the annotations, and recompresses via Huffman encoding. Finally, it sends the resulting file to the fax machine, which prints it.

Because of the limitations of software and hardware available to the project, special adaptations had to be made to an existing UNIX 6.0 operating system. This work required custom drivers and modifications to system calls to provide real-time response.

The SGWS is a real-time program. It must read the touch screen and draw under the pen so that ink appears to flow from the pen. Though the UNIX V6 operating system was not designed to be a real-time system, it does have many features that allow real-time response if the computer that runs it is fast enough. CSM determined that the DEC PDP 11/23 was not fast enough to run standard UNIX V6 and get real-time response. Therefore, CSM modified UNIX to make it act like a real-time system.

Modifying the V6 operating system for real-time action presented CSM staff with a complex problem: When the system was asked to read, one of its computer ports would wait until the requested number of bytes of information was availible. If a user is drawing on the bitpad, however, the SGWS must receive data on several ports, without waiting for information from another station.

To solve this problem, CSM modified a UNIX driver so that when asked to read a port, the system does not wait for data. If no data is available, the read system call returns a zero to the calling program, indicating that no information is available at this time. If some, but not all, of the data requested is availible, it returns that data.

Another major achievement that permits the fast and accurate operation of an individual graphics node is the modification of the UNIX operating-system drivers for DMA. DMA is a hardware technique for moving information between memory and the input/output (I/O) device. Generally, the central processor must regulate this transfer, thus slowing down the movement of information. The DMA technique requires the central processor only to initiate and terminate the process. While information is moving from memory to the I/O device and back again, the central processor is available for other tasks. At this time, the speed of information transfer from memory to I/O device is the maximum available. The significance of this complex process is that the user waits only one second, rather than five, for a new display on the monitor. Given the current hardware constraints, this comes as close to real-time as possible.

2.1.1.4 Automated Briefings

CSM also developed human interfaces for the SGWS software. One purpose of the Teleconferencing System is to allow conference participants in different locations to prepare and present briefings. With the automated-briefing feature, senior officials, often untrained in data processing, can do this, using all the capabilities of the SGWS, despite the system's complexities.

To achieve this ease of use, while giving user's complete control of the capabilities of the system, CSM chose a menu-driven interface. This menu allows participants to select the capabilities they need from the available set of features. Though slightly more time consuming to the participant than typing in commands, this method minimizes the need for extensive training and documentation. To the degree possible, the system is self-explanatory.

Using the automated-briefing capability, participants can select from a wide variety of information sources: sketches, text, graphics, maps or photographs from video disks, and facsimile images. After selecting the desired information, they can send it to other participants.

A briefing can be thought of as a pre-prepared multimedia slide show on the SGWS. With the system in a stand-alone mode, a user can prepare a briefing, archive it, and then present it at some future time. A briefing consists of various pages in the shared notebook that have been arranged in the order in which the conferees will discuss them. When preparing a briefing, the user chooses whether to put a fax, graphic, text, or video-disk frame on a particular page. If fax, graphic, or text is selected, the monitor displays a list of the files avaliable in the chosen form. The user then selects the desired file, which the system places on that page. If video disk is chosen, the monitor asks the user to enter the video-disk frame number or a city name. If a city name is entered, the system searches its locational database to find the frame number for that city. It then places the frame on the notebook page. This process can continue for up to 132 pages.

Once built, a briefing is archived under a name that the user gives it. A menu display allows the user to choose which of the available briefings he or she would like to present. When a briefing begins, all participants see the first page of the briefing on their screens. After they have discussed and annotated this page, pressing the Next Page button on the menu box archives the newly annotated version and brings up page two of the briefing. This process continues until all pages have been discussed. Though all users have access to all controls for the SGWS during a briefing, they need to use only the Next Page and Last Page buttons.

2.1.1.5 SGWS User's Manual

To help senior-level teleconference participants with little or no knowledge of data processing to operate the system, CSM prepared a simple, step-by-step user's manual for the SGWS. The manual describes the functions of the various menus and gives directions for such things as how to start up the software, deal with errors in the file system, set up briefings, send briefings and files to other nodes in the network, and shut down the system.

2.1.2 The Compressed Bandwidth Codec

Understanding the need for a compressed bandwidth codec requires first an appreciation of the requirements of the analog video signal. The communication bandwidth used by a broadcast-quality analog video signal is approximately 6 MHz. If this signal were digitized on a 512 by 512 pixel area, with 16 bits of gray-scale information per pixel, at a sampling rate of 30 times per second, the resulting digital equivalent would be 125.8 Mbps of sampling information. If transmitted, the signal would require 251.6 MHz of bandwidth. To use this amount of bandwidth is prohibitively expensive for all but a few applications and becomes physically impossible when the number of channels begins to increase.

But if the signal is compressed, a frame store is used, and the frame rate is reduced, the quantity of information transmitted, and hence its transmission cost, can be lowered substantially. This means, however, that users must accept some minor degradation in the quality of an image.

The Compression Labs, Inc. (CLI) Sketch Coder, used with the Teleconferencing System, solves this problem because it communicates at only 19.2 kbps. This reduces by 13,000:1 the quantity of information being transmitted. Despite this large reduction in information, however, the codec can still produce a recognizable image of an individual's face at a greatly reduced cost. CSM continued to demonstrate the prototype Teleconferencing System, using the CLI 19.2 kbps codec and has now acquired an initial version of the Widegren 56 kbps codec, which it has integrated into a two-node demonstration system.

The low bandwidth of these codecs also allows the use of readily available data-encryption equipment to provide communications security to the system. In addition, the entire system--video, audio, and graphics--can transmit on a data channel of only 32 kbps for the 19.2 kbps codec and 112 kbps for the 56 kbps codec.

2.2 Communications and Security

Since CSM is now working to transfer the Teleconferencing System to classified facilities, communications security is vital. To insure a smooth transfer to secure sites, CSM has tested the KG-84 encryption device for compatibility with the teleconferencing equipment.

Two tests were required: The first established that there was no data loss or error. In tests totalling an hour none was detected. The second determined the unit's delay. The delay was found to be negligible compared with transmission time, especially if a cross-country link is established.

Satisfied that the KG-84 is compatible with the Teleconferencing System, CSM has provided the software and hardware to interface with equipment supplied by the U.S. government. This interface insures secure digital video, data, and voice lines in the Teleconferencing System without significant delays in data transmission.

CSM studies have established appropriate communications interfaces for the Teleconferencing System; and methods have been developed to provide command, control, and communication during its installation.

3.0 SATELLITE FEASIBILITY STUDY

When another transfer of the DARPA Teleconferencing System was planned, this time for the Navy, CSM commissioned a study by Brigadier General H. R. Johnson (USAF Retired) to describe the feasibility of using satellite communications. Earlier studies had already determined that leased land lines would cost too much. General Johnson's study investigated the relative merits of using C-Band or Ku-Band for transmission from the East Coast to Pearl Harbor.

3.1 Site Evaluation

The earth stations to be installed at Suitland, Maryland, and Pearl Harbor--and possibly at Naval Ocean Systems Command (NOSC), in San Diego, California-- are designed to transmit digital data on two channels at 112 kbps each. The two data streams are composed of 56 kbps from a video codec and 48 kbps from the stereo voice channels and the graphics system.

A bit error rate of ten to the minus seven was established for data transmission. If the video codec divides a frame into 1,000 blocks of 256 pixels each and if half of the blocks need only an 8-bit value transmitted and the other half require 18 bits per block, then an encoded frame requires about 13,000 bits. The stated bit-error rate means far less than one bit per frame in error caused by the transmission medium.

It is assumed that at least a six-meter antenna will be needed to meet the Federal Communications Commission (FCC) two-degree spacing requirement. The low power requirement of the system indicates that a five-watt solid-state amplifier will be adequate.

The purpose of the network design-and-cost study was to devise the most cost-effective approach for a three-node network, using technology available in 1983-1984. When both C-Band and Ku-Band alternatives were considered, the earth station at Ku-Band was determined to cost more in most cases than at C-Band. Though one alternative at Ku-Band was found to cost slightly less for the earth stations, the cost of the space segment turned out to be much higher at Ku-Band than at C-Band.

The overall requirements for this system are reduced reliability/availability numbers and reduced bit-error rates; these, in turn, were translated into antenna size, transmission power, and station-gain/temperature (G/T) parameters. Beyond this point, General Johnson found that the most cost-effective approach was to have companies in the business of supplying and installing earth stations bid on the requirements. Therefore, he recommended choosing the hardware design offered by whatever company proposes to do the job in the most economical way.

To most economically reach the objective, our consultant recommended a three-node, full-mesh network, where each station could transmit to and receive from all of the others. The first demonstration network was to be a single, two-node link between the West Coast and East Coast. Each station was to transmit on a given set of frequencies and have an IF power splitter at the output of the downconverter to separate the transmissions from the other stations according to frequency and direct them to separate demodulators. Each station, then would have had demodulators dedicated to receiving the transmissions from each of the remote stations. The demonstration was to use only one set of demodulators since it would receive from only one remote; however, a four-way IF splitter was to be used at the outset so that transmission frequencies from up to four remotes could be separated and directed to separate demodulators to be installed later.

Thus, as originally conceived, the demonstration network would have been a full-mesh, full-duplex type that would allow all nodes to receive data streams from two cameras at each of the other nodes. In the event, however, the demonstration proved too expensive, so it was decided to install the earth stations at their final destinations in Suitland, Maryland, and Pearl Harbor.

3.2 Conclusion

After a multi-vendor evaluation, General Johnson concluded the satellite study by recommending the purchase of two Vitalink 6.1-meter, five-watt earth stations with space segment, plus network monitoring and maintenance provided by Vitalink. This recommendation is based on technical advantages, such as packaging, all solid-state construction, and a unique dual-channel design, as well as on price. The maintenance program and the 24-hour network monitoring provided with the Vitalink space-segment charge make these stations ideal for a small initial network that is expected to grow over the next few years. The system, as designed, is flexible and will lend itself to a growing network with changing traffic requirements.

4.Ø SPECIAL OPERATIONS PLANNING AID (SOPA)

With the advice and direction of the Contracting Office Representative (COR), CSM provided the following facilities and assisted DARPA's Tactical Technology Office (TTO) in research for the design and development of prototype software, including dataset maintenance, for SOPA.

4.1 Facilities

CSM provided the following capabilities of its Demonstration and Development Facility (DDF):

4.1.1 Computer Facilities

CSM made available its DDF computer facility, with 850 square feet of prepared computer space. The computer room includes a power-distribution panel of 450 amps, connected to a 75-KVA transformer. Each breaker on the panel connects to hardware units via a flexible, grounded cable, permitting relocation of equipment to anywhere within the area.

The computer room has a complete environmental-control system with a maximum of 15 tons of air-conditioning/heating. The air conditioners are each on separate power circuits, permitting independent operation. The heat exchange units connect via copper pipe to a location in the parking garage below and outside of the facility. The design of the climate control system permits humidification and de-humidification of the room, thus keeping the equipment in the best operating environment and decreasing the chance of equipment failure under less than optimal conditions. The total environmental-control system is maintained under subcontract for both emergency and periodic preventive maintenance.

CSM also furnished the hardware required for this research project: a DEC PDP 11/70. The computer has 512 megabytes of MOS memory and two RP04 88 megabyte disc drives, which provides enough capacity for on-line storage and program execution space. The 11/70, with two DH-11 multiplexors, capable of up to 32 independent user-access ports, proved to be big and fast enough to support design and development of prototype software for the SOPA project. Further, up-time performance was guaranteed through a third party maintenance subcontract, which provided two-hour response to emergency maintenance requests and normal monthly preventive servicing.

The computer's operating system was UNIX version 6.0, developed by Bell Laboratories and licensed to the Department of Defense (DOD) on a nonsupport basis. UNIX supports the 'C' language as its primary system level and user compiler. This software proved sufficient to support the prototype development.

4.1.2 Demonstration Facilities

CSM provided demonstration support services in two forms: The first was use of the DDF room. This area has two 5' x 7' large-screen displays, one with a rear-projected 35MM random-access slide projector and the other with a PJ5050B General Electric light valve. The GE light valve can be switched between multiple sources and can display both National Television Standards Code (NTSC) and Red-Green-Blue (RGB) video formats, thereby permitting computer-generated images to be shown directly on one of the large screens.

The second demonstration facility was the CSM/DDF Videolab, set up for Electronic News Gathering (ENG), video-editing, and dubbing. The prototype demonstration was captured on videotape via the ENG equipment and edited down to the desired content for use as a briefing aid. The resulting videotape production could then be mailed to remote areas to give those who could not attend local briefings an accurate picture of the research project, complete with sound and pictures of the live system at work. Since most people are comfortable with television, this method of videotaping demos and briefings has proved quite effective at both saving travel time and communicating the message.

4.2 Staff

CSM staff, with expertise in computer systems operations, operating systems and applications programming, and videotape production and editing, assisted in the use of the DDF's facilities, thus relieving development-contractor personnel from the operating tasks necessary in using these facilities.

The staff member assigned to support the operations of the 11/70 provided weekly file-system archives. Because the users did not have to divert attention from prototype development to perform this task, these archives saved them time. Also, the CSM staff member was available to do daily operations, such as restarting the computer whenever necessary.

The CSM Systems Analyst assigned to this activity was available to support the research with programming assistance at both the applications and system-internals levels. His expert advice enabled the researcher/user to resolve problems unique to the 11/70 and UNIX and to follow correct procedures to produce the desired results.

Finally, a Video Engineer assisted in the production of videotapes and the use of video equipment. Like the other CSM/DDF staff members, he made himself available to perform tasks that the developer could not do because he lacked time or was not familiar with the equipment.

4.3 Software Support

CSM prepared a bootable copy of UNIX System V, level 1.0, to facilitate transfer of CACI-developed software to the operational activity at Fort Bragg, North Carolina. This upgrade required developing and installing drivers, changing applications programs, and porting applications software from the DDF programming environment to the new environment.

In addition, after evaluating DDF requirements, CSM technical staff recommended that DDF upgrade its operating system from UNIX 6.0 to UNIX System V, level 2.0.

5.0 OTHER SUPPORT ACTIVITIES

CSM technical staff assisted with computer-related simulations and with hardware and software evaluations to support the needs of the COR and other elements of these research studies. In addition, the company purchased equipment to test program visualization tools in a working programming environment.

6.0 CONCLUSION

Work continues on all three projects. In coming months, CSM will install the SGWS at Wright-Patterson Air Force Base and Fort Meade; expansion of the network to two other sites is now being discussed. In addition, planned enhancements to the system will speed transmission of facsimile images and improve the quality of hardcopies.

As recommended in the Satellite Feasibility Study, Vitalink, at the direction of DARPA, will install earth stations for the naval Teleconferencing System at Suitland, Maryland, and Pearl Harbor.

Finally, for SOPA, CSM will upgrade the DDF operating system from UNIX 6.0 to UNIX System V, level 2.0, as recommended by CSM technical staff.

APPENDIX

Shared Graphics Workspace Equipment
for AF/FTD (per site)
Original Configuration

1	ADM-3a terminal
1	RLG Binary UNIX license
1	AED 512 graphics system w/Q-bus interface
1	Tektronix HR250-1 RGB monitor
1	Elographics touchscreen (stylus operation)
1	Elographics E271-60 Controller
1	Pioneer Videodisc Player
1	Pioneer SIA (Interface Adapter)
1	Harris 506 TBC
1	Panasonic WV-3300 Switcher/Keyer
1	Computer equipment cabinet
1	PDP 11/23
1	RLV21-AK -RL02 drive & Controller
1	BDV11 Boot Module
1	KDF11 -LSI
2	DLV11-J
1	256kB MOS RAM
1	DPV11 Fax Interface
1	CSM Menubox
1	CSM Menubox Controller
1	CSM Fax Interface
1	Rapicom R-3300
1	Pod Stand (vertical type)
1	Conference Table
1	Chair