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Semi-Annual Technical Report:

The Design, Development and Application of Advanced Video and Microcomputer-Based Command and Control (C2) Systems

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Videodisc systems vary in capability but most are applicable to Command and Control requirements especially training and data retrieval. A professional non-broadcast video system can be configured at a cost less than $75K. The Hand-Held Computer has applications for DoD but not without certain reservations. A low-cost, off-the-shelf package may be assembled to build an electronic notepad.

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SEMI-ANNUAL TECHNICAL REPORT:

THE DESIGN, DEVELOPMENT AND APPLICATION OF ADVANCED VIDEO AND MICROCOMPUTER-BASED COMMAND AND CONTROL (C2) SYSTEMS

ARPA ORDER NO.:	3829
CONTRACTOR:	Computer Systems Management, Inc. 1300 Wilson Boulevard, Suite 100 Arlington, Virginia 22209
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SUMMARY

This Semi-Annual Technical Report covers the period from October 1, 1981 to March 31, 1982. The tasks/objectives and/or purposes of the overall project are connected with the design, development, demonstration and transfer of advanced computer-based command and control (C2), video-teleconferencing, and counter-terrorist systems. This report covers work in the area of video-based and microprocessor systems research, analysis, and applications. The technical problems addressed include: the rapidly evolving videodisc world, instituting a government-owned, company-operated video laboratory (Videolab), research into applications for the hand-held computer, and a report on the construction of an electronically simulated notepad. Other discussions include how developments in these areas can be exploited for Department of Defense (DoD) use for group problem-solving, video telecommunications, training, and information management, among other areas. The general methods employed include two surveys and two reports, each matching results to DOD functions and requirements. Technical summaries include a set of recommendations regarding how current and future video and microprocessor technology can be used or enhanced in a variety of defense contexts. Future research will summarize and integrate all of the work performed during the two-year contract period.

CONTENTS

1.0 INTRODUCTION

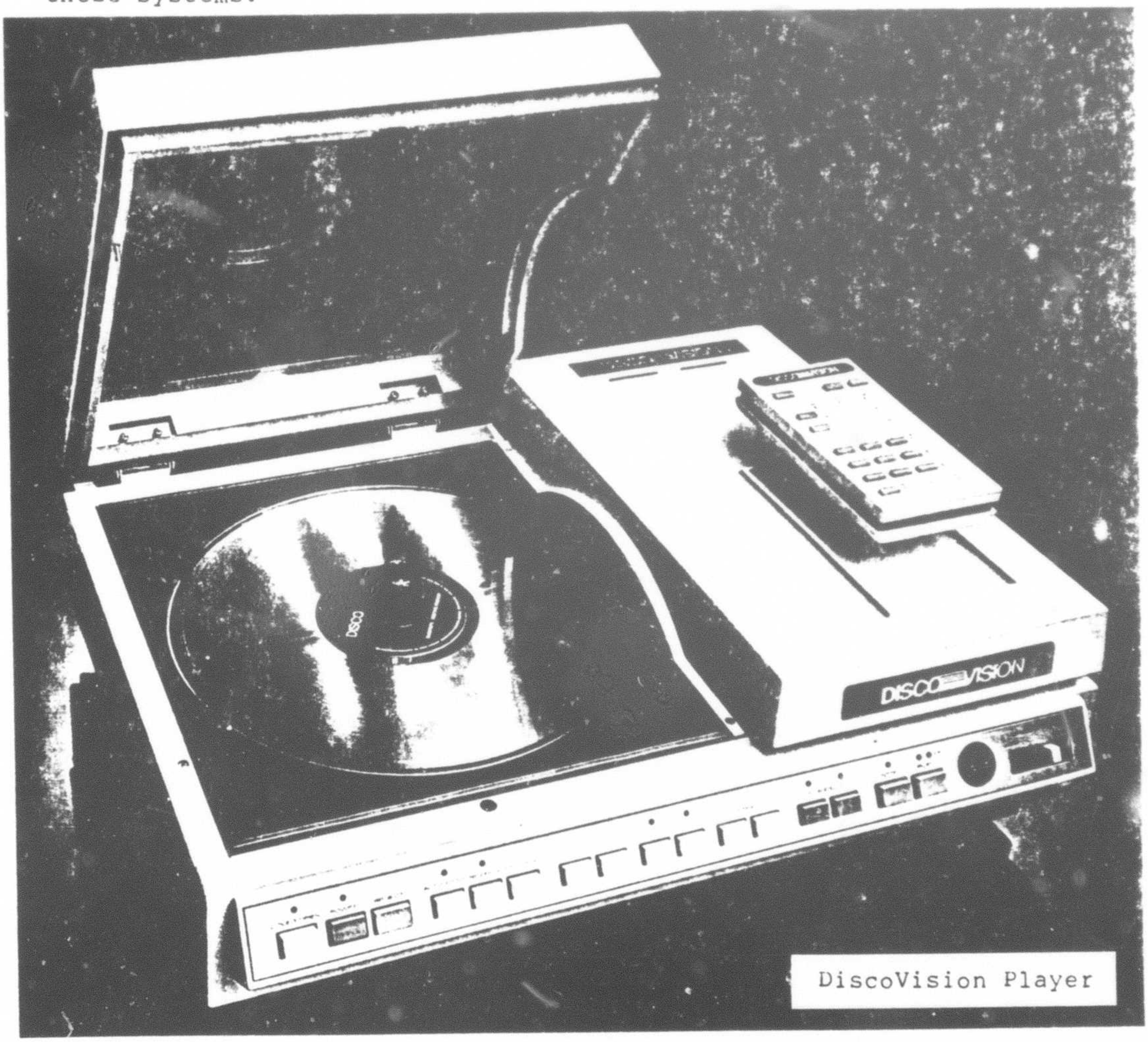
Within the scope of the current contract, Computer Systems Management, Inc. (CSM) is tasked to perform a myriad of projects relating to state-of-the-art computer software design, hardware engineering, and video technology. In its research, CSM continues to uncover positive proof of the merger between the video arts and computer science. These two technologies are steadily advancing and require monitoring on a daily basis. It is to the credit of the Department of Defense (DoD) that DARPA continues to support research into new applications which might be discovered as these technologies continue to evolve.

This report, in part, deals with several on-going efforts at CSM to identify, develop and apply advanced design principles to the enhancement of computer-based communications and command and control analytic, counter-terrorism, and video-teleconferencing systems. The following sections will describe work performed in the areas of video technology and microcomputer applications in C2. Although this report does not completely encompass all the on-going efforts at CSM, it does however, represent the typical functions being performed and the results or findings from these efforts. Further reports will cover other projects not yet completed and present new findings of interest to DoD.

2.0 CURRENT AND EMERGING VIDEO TECHNOLOGY

2.1 Alternative Videodisc Systems

The MCA/DiscoVision (Pioneer) videodisc system has been incorporated into numerous DARPA projects. CSM has been involved in the development, demonstration, and transfer of several of these systems.



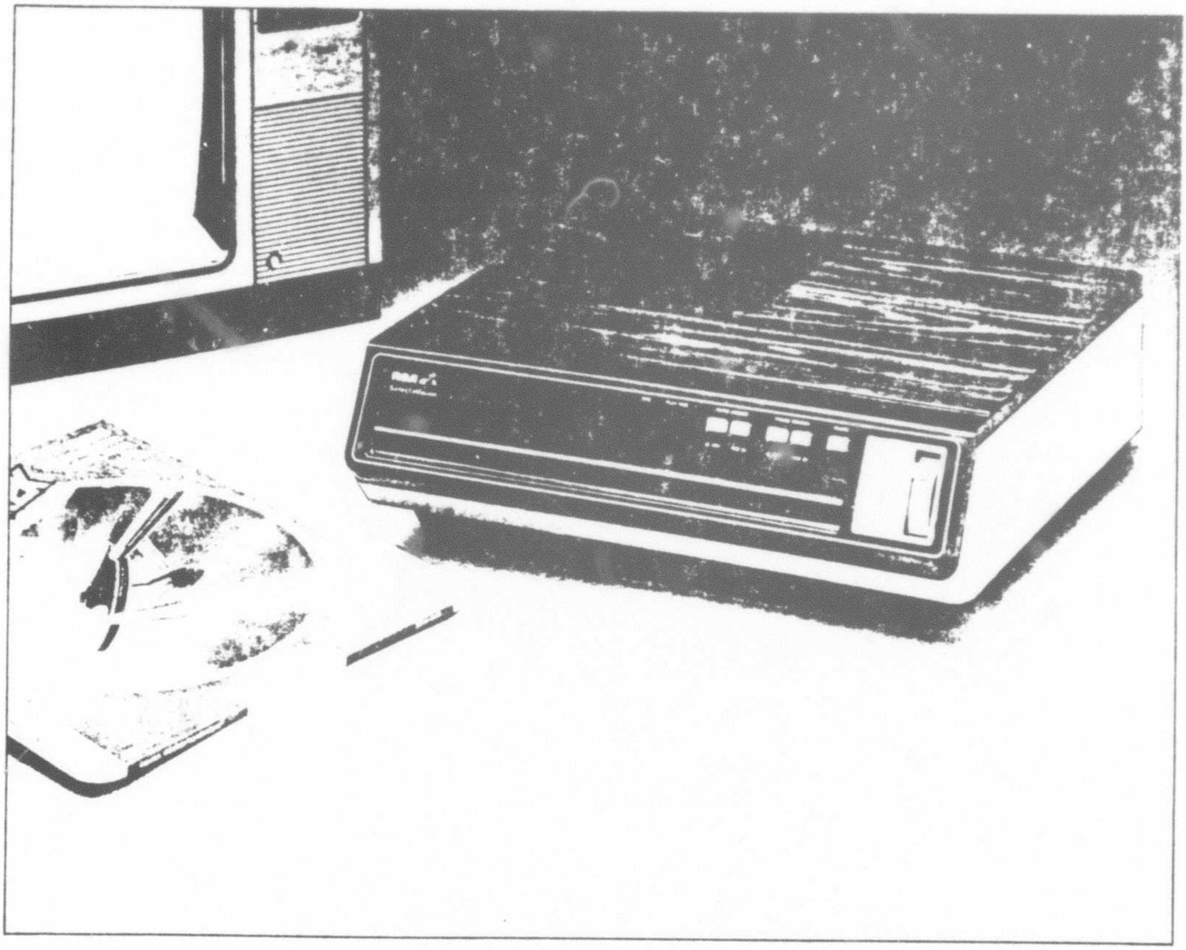
DiscoVision Player

Part of our role is to keep abreast of all new research and commercial products which may be of value to DARPA's projects. Accordingly, CSM has been investigating some alternatives to the reflective optical videodisc system:, CED, VHD, and tranmissive. Each system has its own advantages and disadvantages. Each differs in price, user features, frame capacity/accessibility, and custom pressing facilities.

2.1.1 Capacitance Electronic Disc (CED)

A simple and inexpensive alternative to the DiscoVision player is the Capacitance Electronic Disc (CED). It is a consumer-line "needle and groove" technology whose major promoter is RCA. Their "SelectaVision" disc player has been on the market for twelve months. Both the player and the disc differ significantly from DiscoVision's optical disc system. RCA's CED uses a stylus in a groove to read the signal (much like a conventional record player), instead of a laser. The CED disc is mechanically loaded into the player, not manually placed on a platter. And the CED system has fewer user controls. (It offers "visual search" at 16x speed forward or back, and a fake freezeframe, but no frame search or programmability).

Its limited number of user features may seem like a liability until one considers the problems faced by DiscoVision users. The myriad of buttons on the DVA machine confuses the user. Pushing the wrong button (say, on an interactive instructional disc) can "hang up" the device. First time users who forget to lock down the optical disc before playing it can create irrepairable damage. (The CED loading system prevents this). Finally, the DiscoVision system has complex alignment problems which are virtually eliminated by the CED stylus. Clearly, the grooved CED system's main advantage is its simplicity.



RCA CED Player

The grooved CED can hold more motion sequences than the optical disc, but ironically, it stores fewer still frames. Both are due to the grooves. Each revolution of the CED disc holds four frames. If the revolution holds four successive identical frames, the stylus can be commanded to spin around continuously in the same groove and give the illusion of a still frame (which is unstable at best). Since each side of the disc holds 27,000 revolutions, each side can hold 27,000 "fake" still frames. This is exactly half the capacity of the reflective optical disc with 54,000 "real" still frames. But remember, the total ACTUAL frames per side on a grooved CED disc is:

4 frames per rev. x 27,000 rev. = 108,000 frames per side

That's TWICE the optical videodisc's capacity of 54,000 and twice the playing time. A CED can hold up to 60 minutes of information per side, compared to the optical disc's 30 minutes per side.

Like any typical record album, the stylus will wear down the grooves and degrade the signal. Although research is inconclusive, the RCA factory has played a disc a million times and it still maintained acceptable quality. They have also played a "still frame" up to two hours without break-up. But their competition disputes these figures.

Presently the CED system offers no search-command/random-access capability, but it is being considered. Interface with a microcomputer driving the disc is not currently being considered by RCA, however they believe that it is not outside the realm of possibility. In fact, an article in "Popular Electronics" notes that each electronic field has 26 bits of unused digital information that could be exploited. Stereo and binaural sound will be available in RCA's 1982 "Stereo Version".

The cost of the SelectaVision player is lower than the DiscoVision player because it has no fancy controls or complicated servo. The cost of producing grooved CED discs is cheaper too.

CED disc mastering and pressing is similar to traditional LP album pressing. Carbonized plastic is imprinted with grooves on both sides as it passes between metal molds. This is simpler than optical disc mastering wich requires TWO aluminum platters being pressed on one side each, then glueing the two together, and sealing the resultant sandwich in plastic.

Although DVA prefers a 2-inch videotape pre-master, CED prefers 1-inch. This is quite attractive to many producers since 1-inch is more affordable, both as an original production format and as a pre-mastering medium. Should 35mm or 70mm film or 3/4 or 2-inch videotape be submitted, it is transferred onto 1-inch at the CED plant.

Through 1982, two grooved CED disc mastering facilities will exist. The one currently in operation is RCA's plant in Indianapolis. The second is being built by Columbia, under license by RCA, in Carrolton, Georgia. CBS presently operates an experimental facility in Stanford, Conn., which will close when Carrolton opens. 3M is negotiating a license with RCA.

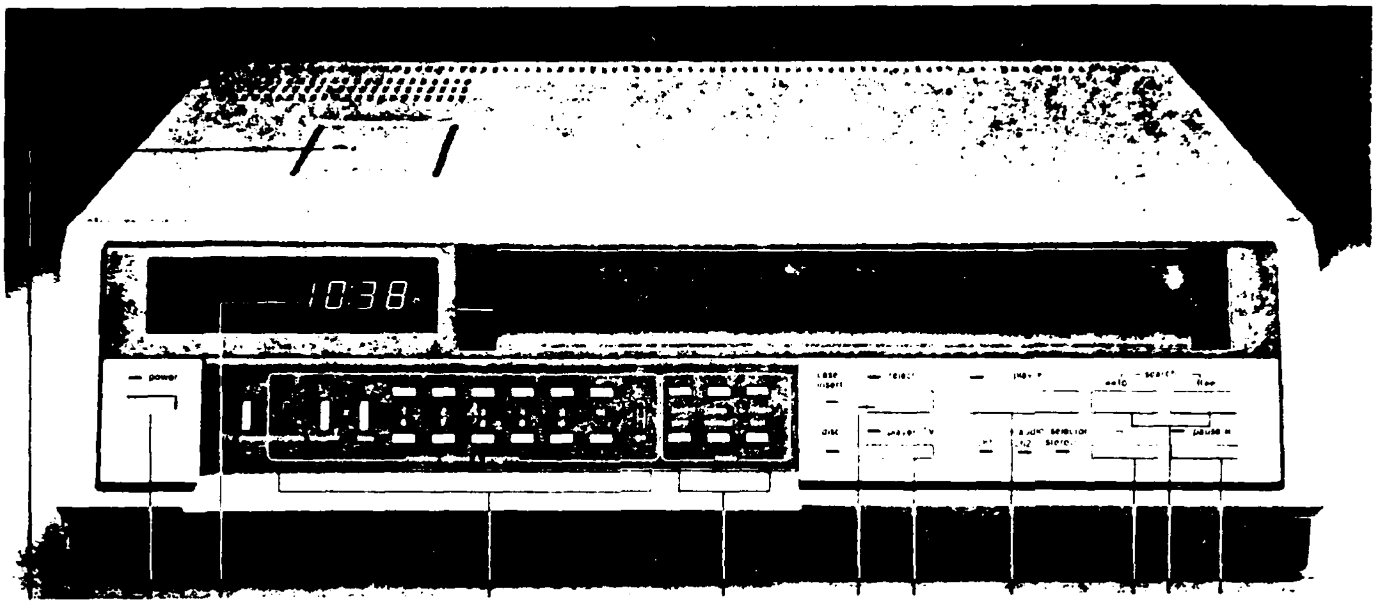
Both the RCA and CBS facilities will devote their resources full-time to consumer disc production for the next couple of years. Neither is considering "custom" mastering for outside clients until after that time. Neither is capable of handling classified materials, but both are secure against copyright pirating.

Building your own mastering facility is not an easy task. It requires a "clean room" and some very precise machinery, due to the fact that 38 CED grooves can fit inside one conventional record groove. About $20 million is the cost estimate.

2.1.2 Video High Density (VHD) System

A newer GROOVELESS CED system is offered, primarily by JVC and Panasonic. Both grooved and grooveless systems use the same audio/video signal-measuring concept, thus both are CED systems. But they differ in the manner in which they stay on track. The pointed stylus of the grooved system maintains its location by riding in a groove. The grooveless system, however, employs a flat stylus that reads electronic directional impulses which border the audio/video signal tracks on the disc. This difference is important because the grooveless concept permits a wider variety of features.

The grooveless technology, called VHD (Video High Density), is a Matsushita concept. JVC, Panasonic, General Electric, and Quasar plan to introduce their VHD machines in the Fall of 1982.



Panasonic's VHD Player

All have very similar features like stereo/binaural sound and fast-search (forward and back). All VHD systems have random access (which the grooved CED system does not). Its accuracy of accessibility is only +/- 15 frames because the user does NOT call up the frame number like on the DiscoVision player. Rather, the user accesses the desired location by keying in how far into the program the scene is found (that is, the number of minutes and seconds from the program's beginning). In 1983, to-the-frame accuracy is planned.

VHD offers 54,000 perfectly stable still frames per side. That's equal to the DiscoVision player. Actually, VHD holds

108,000 frames per side, but it takes two frames to make one "still frame". Here's why: The VHD holds 54,000 tracks per side, with two frames laid out on each track (54,000 x 2 = 108,000). Since the stylus must read one full track before advancing to the next track, it reads two frames before moving on. In still frame mode, the stylus spins around continuously in the same track. If the two frames in the track are identical, the resulting image looks like one frozen picture. If they're NOT identical, the images flutter.

This design gives VHD 60 minutes of motion per side, compared to the optical disc's 30 minutes. This explains why they call it Video High Density, since the VHD packs all this information on a 10 inch disc, compared to the optical disc's twelve inches.

VHD's perfect still frames are better quality than the grooved system's "fake" still frames. Since the grooved system uses a pointed stylus running along one long continuous track, it creates a still frame by kicking the stylus over the lip of the groove, thus replaying the same scene. At every "kickover", a jitter appears in the image. Every time it jumps, it wears down the ridge between the paths, until eventually a permanent scratch remains. This creates a locked groove, resulting in a "broken record" effect.

The VHD system, however, uses a flat stylus running on a flat disc. (Again, it stays on track by reading electronic directional impulses). Since there is minimal physical contact between stylus and disc, there's no ridge to wear down, no scratching, and no jittery image. It is also important to note that the physical wear is so minimal that the life of the VHD disc and stylus is much longer than that of the CED.

The VHD mastering/pressing process begins in a clean room. A laser etches a glass master disc which is coated with photo resist material. While spiralling inward at a constant 900 rpm's, the laser splits in two. One half cuts audio-video "pits". The other half makes tracking pits. From the glass master, a metal negative stamp is made. Using conventional audio methods, the stamp presses thousands of electro-conductive plastic videodiscs.

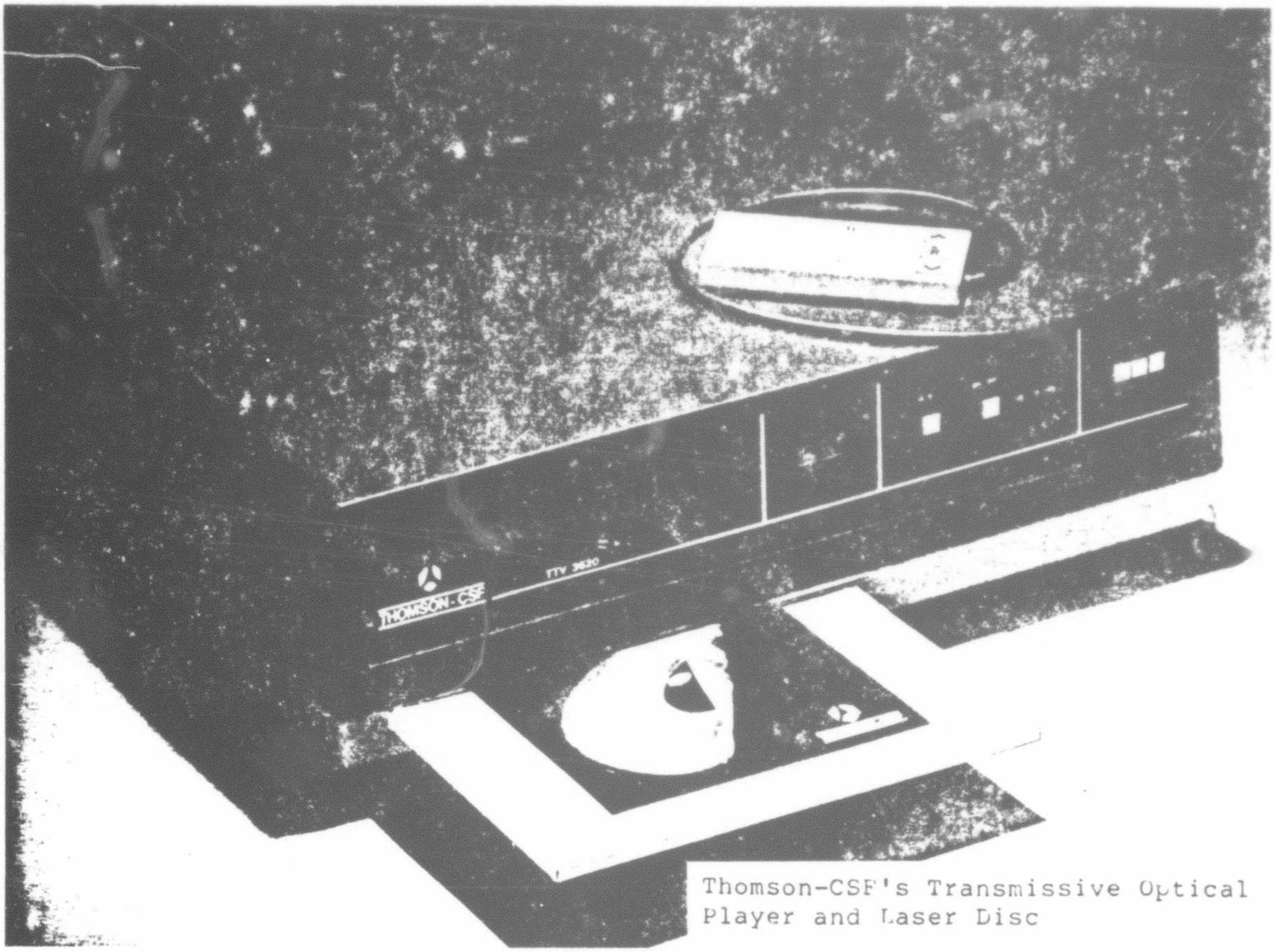
Presently, two VHD pressing facilities exist. One is in Japan, the other is in Irvine, California. The $12-million Irvine factory is operated by VHD Disc Manufacturing Co., a joint venture backed by JVC, Panasonic, GE, and other VHD hardware manufacturers. Presently, this company and its sister company, a program development firm called VHD Programs, Inc. are devoting their time to acquiring and pressing titles from the major film distributors. However, they are considering custom pressing for industrial clients beginning as early as June, 1982. (By that time, two new plants--in England and Germany--will be taking some of the burden off the Irvine plant. In 1983, a new major VHD pressing facility is planned for construction in the Southwestern U.S.). Pressing orders at VHD Manufacturing currently have a two-month turnaround. After June of 1982, it will take less than three weeks. 3M is considering custom VHD disc-pressing with a similar turnaround time.

2.1.3 The Transmissive Optical Videodisc

There is a "high-end" alternative to DiscoVision's reflective optical videodisc system, the Thomson-CSF transmissive optical videodisc system.

Many people might not have heard much about the Thomson system because it's a late-comer to the videodisc competition. Its series 100 had such serious engineering problems that Thomson had been keeping a low profile. Thomson also had some marketing and distribution problems that precluded a full promotional campaign. Soon all those troubles should clear up. Thomson has a new line, the series 4000, that has eliminated previous engineering problems. In October 1981, 3M company signed an agreement to sell and service the Thomson player, as well as to manufacture the discs.

The Thomson system is very similar to the MCA/DiscoVision (Pioneer) system. Both have a wide variety of features because both use optical lasers to read the signal. Whereas the DVA (Pioneer) machine reads the laser's signal after reflecting it off a shiny disc, the Thomson player reads the signal after it is transmitted through a transparent disc. That's why DVA is a REFLECTIVE, optical disc player and Thomson is a TRANSMISSIVE optical disc player.



Thomson-CSF's Transmissive Optical Player and Laser Disc

But here's the big difference. To watch all the reflective disc's 108,000 still frames and 60 minutes of play, you have to flip the disc over (54,000/30 per side). To watch the transmissive disc's 108,000 frames and 60 minutes, you don't have to flip it over. That's because the transmissive laser moves along X,Y, and Z axes. After playing the top side, it automatically refocuses through the transparent disc and plays the bottom side. This flexibility means that the transmissive player can randomly access (to-the-frame) any of its 108,000 frames in less than 3 seconds. With twice the accessibility of the reflective system, the University of Iowa, US Army, and American Medical Association have already begun investigating its archival applications. (Some employ Apple microcomputer interfaces alongside the player's internal microprocessor).

The Thomson player is an industrial product, it is not designed for consumer use. Its complex technology increases its industrial applications, increases the number of potential technical problems, and increases the player's cost. But it simplifies the disc mastering process since it is not necessary to make metal sandwiches as for reflective discs.

The disc-mastering process requires a clean room where a laser cuts pits into a 1/4-inch polished glass "mother" disc covered with photo-sensitive chemicals. A negative nickel "father" mold is made from the mother through an electrolytic process. The father is then used to stamp out thousands of thermoformed, transparent, bendable plastic discs that last a lifetime.

Presently, one transmissive disc-pressing facility is in operation: 3M's plant in St. Paul, Minnesota. (3M intends to add another facility if the volume warrants it). The facility is devoted almost entirely to custom-pressing for industrial clients. Thus they're proposing excellent terms and time tables. After January 1982, the mastering process will take about two weeks and cost about $1000.

2.1.4 Summary

By comparison, the optical reflective system has been on the market the longest and has the most features (including to-the-frame random access, 54,000 still frames, 30 minutes per side, and no-wear discs). It has good image quality, yet it has some disturbing alignment problems. Finally, custom disc pressing can be handled in the United States.

The grooved CED recently entered the market and has the fewest features (including 27,000 "fake" still frames and 60 minutes per side on a shortlife plastic disc). No random access is planned in the near future. CED has the poorest image quality, very few design problems, and the lowest prices for hardware, mastering, and individual discs. There are no plans for CED custom disc mastering until 1983.

The middle-of-the-road system is the VHD system: moderate price, good image quality, only a few design/concept problems, and a good number of features, including 54,000 still frames and 60 minutes on a relatively long-lasting plastic disc. Current random access capability brings the user to within +/- 15 frames, but plans are under way to improve that. Custom disc mastering may become available in the U.S after June 1982.

The high-end system is the transmissive optical system. It is the most expensive, the most complex system with the most design problems. It has a wide variety of features, including

108,000 individual still frames available for random access in less than 3 seconds. Relatively low cost and rapid turn-around mastering service is scheduled for early 1982.

It is clear to see that each system has its own benefits and features, which must be weighed in light of the particular job to be done.

2.2 Videotape Applications in C2

"I see what you mean!" More and more often, that's how people respond when DARPA explains the latest projects from the Systems Sciences Division. "I SEE what you mean."

With greater frequency, the Department of Defense depends upon audiovisual materials, videotapes in particular, to introduce their latest research projects. Using colorful, edited, moving pictures, project managers have found a concise way to accurately explain products and concepts which once required volumes of textual description.

Yet producing videotapes can be a costly, time-consuming effort when outside consultants are brought in on a project-by-project basis. SSD has reduced these expenses by retaining the services of a Government Owned, Company Operated (GOCO) video production system. With a $75,000 investment in equipment plus two staffers on contract, four needs common to all R&D managers are being met by Computer Systems Management, Inc.

1. IMPROVE COMMUNICATION. Need to improve message quality by translating "hi-tech jargon" into general technical terms. Need to improve image quality without expending heavy funds on special equipment.
2. REDUCE COSTS. Need to reduce the costs of producing demonstration videotapes.
3. REDUCE COSTS. Need to reduce the turnaround time for

locating, generating, and duplicating specialized or limited-quantity audiovisual materials.

4. REDUCE TIME. Need to reduce the time and costs related to transporting project managers and inquirers to briefings.

Each problem was translated into equipment, personnel, and procedural requirements. Based upon these requirements, approaches for solving each problem were developed. The umbrella term for the chosen solutions is "Videolab".

The Videolab provides creative services like video scriptwriting, electronic recording, switching/mixing, and tape editing. Multi-media display and duplication services include videocassette (1/2" and 3/4"), videodisc, slides, overhead transparencies, Poloroid hardcopy, motion pictures, CRT's and large-screen video. The Videolab gives engineering assistance on computer/video signal interface. It also offers a library service for distributing videotapes and it maintains an AV resource file of companies performing specialized audiovisual services.

The Videolab is part of the DDF. By combining its diverse services with those of the DDF, Computer Systems Management, Inc. is helping project managers to improve their communications while lowering costs, saving time, and reducing travel.

2.2.1 CSM Videolab Services

Managers of Research & Development projects spend much of their time describing their lastest results. In DARPA's case, whenever they received a reasonable inquiry, a project manager elected to invite the inquirer and his staff to attend a briefing. The number of inquiries determined the number of briefings, each lasting 30 to 90 minutes. The minutes added up quickly.

Long distance requests for information were handled differently. Project managers would spend valuable time on the phone explaining what the project was about, what it looked like, and how it worked. Both the briefings and the phone calls were inordinately time consuming, particularly when describing that which could be better understood using pictures.

To reduce the length of the briefings, project managers began using videotaped product demonstrations along with their slides and overhead transparencies. Then project managers realized they could delete a number of briefings altogether by simply mailing out these same "demo tapes" and following up with a brief phone call.

Likewise, they could cut down on the length of telephone inquiries by sending out a tape. Clearly, videotapes could do much of the explaining while freeing up the project manager's time for more important research opportunities.

Unfortunately, putting the tapes together was not quite so simple. And for a number of reasons, the programs were not always as effective as hoped for.

2.2.1.1 Style and Quality

Some of DoD's larger contractors had complete TV studios which occasionally produced tapes about projects performed for the sponsor. If the sponsor needed a tape from one of its smaller contractors, the smaller firm hired an independent production company for each production. Very small contractors seldom could afford production costs and simply rented video equipment to make their own "home movie" style videotapes.

As one might expect, program costs and turnaround times varied. Production values were mixed. And image quality was inconsistent. Some of these videotapes were unedited "point and shoot" productions made on low-quality home video equipment. A few had non-standard sync, making them impossible to view. Others were so full of "high-tech" jargon that they were uncomprehensible. Still others were hard-sell commercials unsuitable for briefings. Something needed to be done to iron out these inconsistencies.

2.2.1.2 In-house Staff

It soon became apparent that managers could be well-served by having a video production staff under their editorial and technical control. This staff could produce tapes to suit their briefing styles, meeting objectives, and other requirements while providing consistently good technical standards.

2.2.1.3 Hardware/Software Team

At the most basic level, the Videolab consists of people who are familiar with video production and related audiovisual services. They are the Media Specialist and the Media Technician.

The Media Specialist is the "software" person. His responsibilities include project analysis, producing, scriptwriting, directing, and editing. A familiarity with technical writing is particularly useful since much of the writing involves translating drab engineering proposals into interesting, concise, and highly visual programs. Since such translations often require special materials to convey technical data, knowledge of local and national production support services is also helpful.

Tapping these skills, the Media Specialist develops programs tailored to the needs and style of the particular briefing situation. In this way, he helps managers avoid the dread of showing sub-standard productions, over-technical "shop-talk", or hard-sell commercials.

The Media Technician is the "hardware" person. His responsibilities include specifying/integrating equipment, equipment maintenance, camera/audio/switcher operation, video engineering, and tape duplication. Knowledge of electronics and computer/video interface is particularly helpful. He sets engineering standards for video productions and ensures that all productions meet acceptable technical quality levels.

Together, this team has a broad range of talents within the video discipline. They use these talents to improve the technical and aesthetic quality of the videotapes used in project briefings. This in turn enhances the overall professionalism of DoD communications.

2.2.2 Videolab Equipment

When the Media staff was brought onboard, there was no video equipment. The Media Specialist made programs by renting recording equipment and editing time. Good quality productions were made, but at considerable expense.

2.2.2.1 The High Cost of Rentals

Renting time and facilities was expensive. In fact, even the simplest one-day shoot required a basic field recording system costing at least $500 a day, and one day of editing at $600 a day minimum. Even making a single edit required a minimum investment of $90 for an hour in the editing suite. At those rates, an organization could buy its own equipment for the same price as renting it for just a couple of months.

2.2.2.2 In-House Video Equipment

The task then was to assemble a good quality video production system without expending excessive funds. The key words were "excessive" and "quality". Broadcast-level equipment was considered excessively expensive. Yet image quality had to be good enough to satisfy the high expectations of the intended audience.

This put CSM in the position of looking for equipment in the product line know as "professional quality" or "non-broadcast" video. Every video manufacturer offers something in this category. With so much to choose from, the Media staff could mix and match products so that they met the Videoalab's production philosophy:

1. PORTABLE. Most of the recording would be done outside the studio. Therefore, the Videolab did not need the typical array of immobile studio equipment like heavy cameras, lighting grids, intercom systems, and other costly items.
2. FLEXIBLE. The entire system had to be flexible enough to be reconfigured if needed for special projects. For example, it needed to be disassembled in minutes and

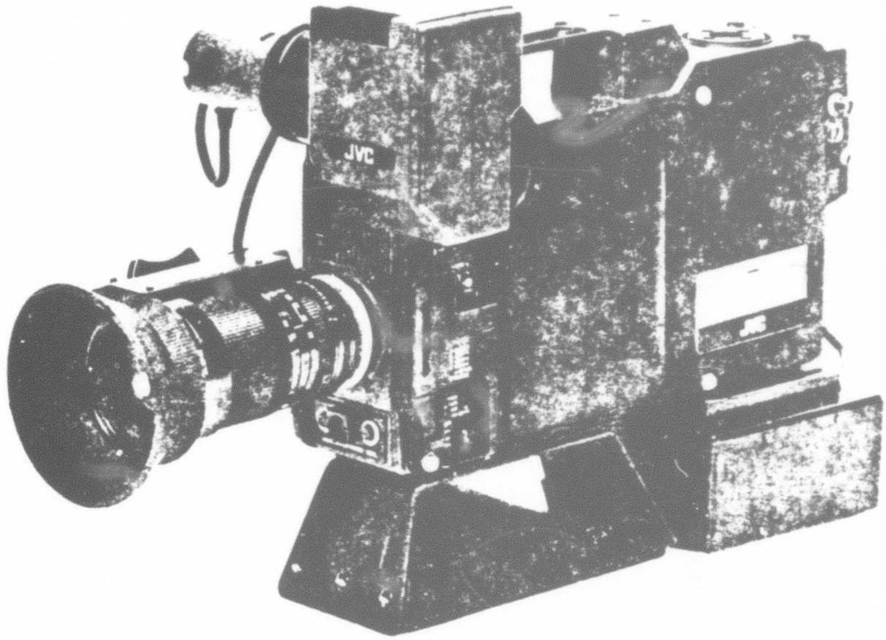
reassembled in a secure room for special "classified" productions.

3. INEXPENSIVE. System expandability and long equipment life was of little importance since the Videolab contract lasted only two years. Thus costly expandability options were disregarded in favor of less expensive equipment.
4. COMPUTER-ORIENTED CONTENT. Special consideration was given to computer/video interface equipment since the programs dealt largely with computers.
5. FIELD-ORIENTED RECORDING. Most of the content would be shot EFP-style. (Electronic Field Production means single-camera film-style shooting done outside a studio.) The portable production equipment had to be sturdy, compact, and require little maintenance.
6. EDIT-ORIENTED SWITCHING. Since CSM would not have multiple cameras, then the switcher needn't be configured in the in the conventional manner. Rather, it should be configured as a post-production switcher to facilitate videotape editing.

The seventh constraint was a budget of $75,000. Five years ago, that figure would have been impossible to work with. Now however, it is quite acceptable for the lower end of the non-broadcast equipment product line. (Manufacturers have made great strides in improving quality while lowering costs for such equipment.)

2.2.2.3 Low-cost, Portable Video Gear

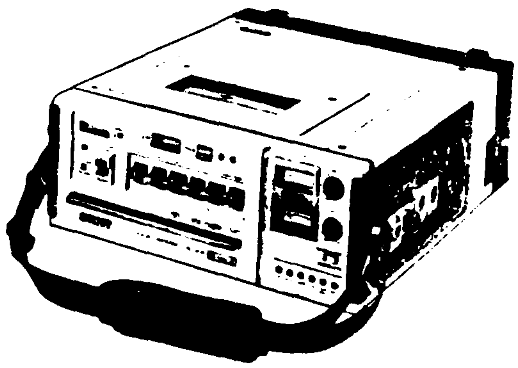
Based on these requirements, the Media staff selected its equipment from a number of reputable manufacturers.



JVC KY-2000 Color Video Camera

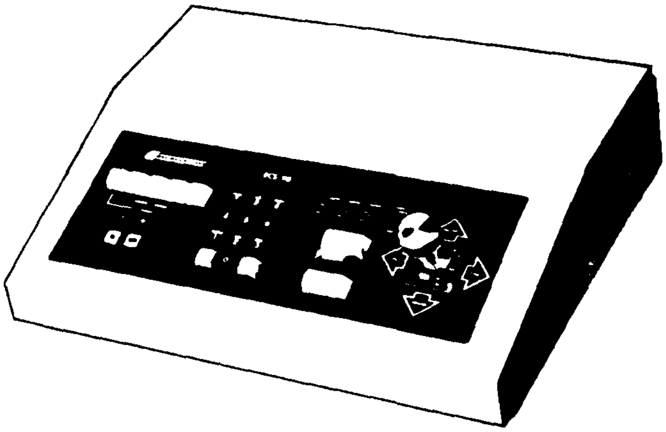
The JVC KY-2700 camera was a bargain. The industry's most popular professional camera, the JVC KY-2000, was being replaced by two new similar models, the KY-1900 and the KY-2700. The new 1900 was almost as good as the earlier model and cost less, but was not yet on the market. The 2700 had better image quality than the KY-2000, was readily available, and was "on sale" for the same price as its predecessor. In addition, it was better than its competitors at recording the color red. (CRT's have a hard time producing red and cameras have a hard time capturing it.) Clearly, the KY-2700 was the best value for our needs.

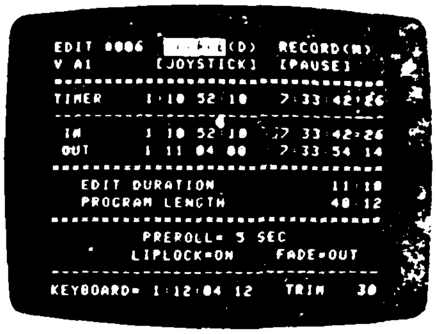
The Sony BVU-110 portable videotape recorder was the one "Rolls Royce" on the equipment list. It's a broadcast-quality machine acclaimed for its durability in the field. Since CSM planned to have only one field recorder, down-time for repairs would be intolerable. Purchasing the 110 reduced the likelihood of problems needing fixing.



Sony BVU-110 Portable Videotape Recorder

The Convergence ECS-90 was the lowest-priced computerizer videotape editor-controller on the market. It was a step above conventional "cuts only" controllers, but did not have the add-on options and special effects of more expensive models. The switcher, as configured for editing, assumed these special functions instead.

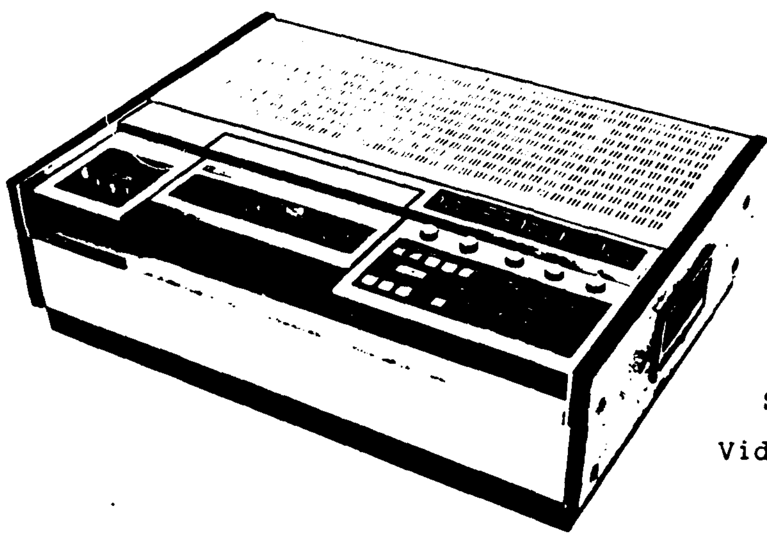




Convergence ECS-90 Edit Controller

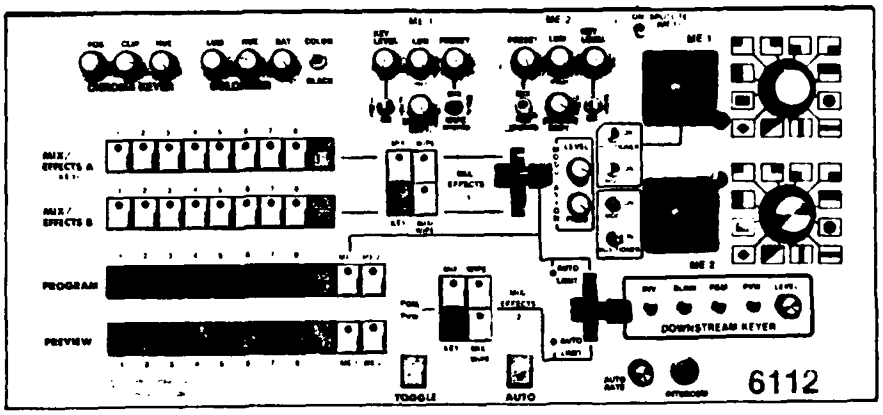
Convergence ECS-90
Edit Control Monitor

We chose the tried-and-true Sony VO-2860A videotape recorders for the editing decks. Though they're somewhat ineffficent when hooked up with a computer editor, they're easy to repair and to find spare parts for. In fact, these decks can be found everywhere. So in an emergency, it would be easy to find a stand-in.



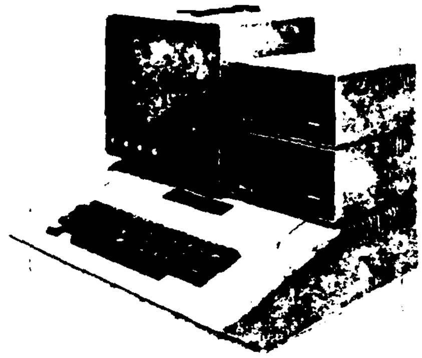
Sony VO-2860A
Videotape Recorder

The Crosspoint Latch 6112 switcher was a real value. It had many more special effects (downstream keyer, spotlighter, soft-edge, borders, and chroma-key encoded/RGB) than other models in the same price range. And it all came in one compact box.



Crosspoint Latch 6112 Video Switcher

For titling, we decided upon an Apple microcomputer with a VAL VB-3 adapter board that makes the Apple's signal compatible with the Videolab's signal. The lettering produced by the Apple has some resolution problems, but due to floppy disc technology, it can offer an infinite choice of lettering styles. (Conventional character generators in the same price range offer only two styles.) Plus, the Apple could draw diagrams, animate sequences, and type scripts. The final reason for selecting the Apple was that much of the work done for DARPA was being done using Apples. Thus we could take anything already existing on floppy disc and record it directly onto tape.

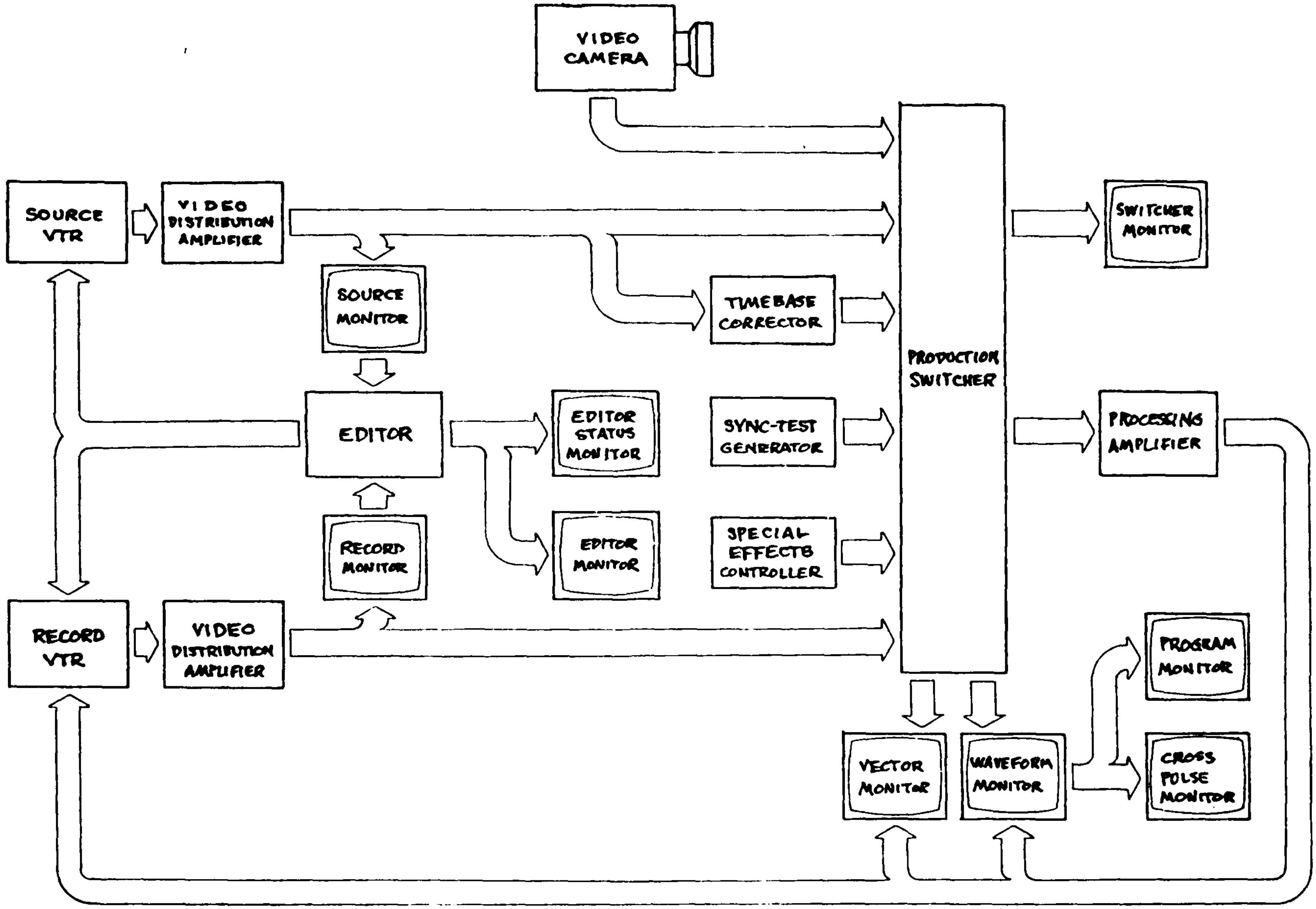


Above: Apple II plus Microcomputer
Left: Winstead studio equipment racks

It is quite common for a switching system to have a large, expensive program monitor as the main monitor in the system. We chose to forgo the expense and bought two inexpensive Videotek VM-12RA monitors. We also saved money by eliminating a patch panel; we used the switcher to do the signal delegating instead. With these savings, we had enough money to buy standard test equipment (waveform monitor, sync generator, vectorscope). Basic audio equipment included a turntable, amplifier, mixer, and speakers.

The housing of the switching/editing equipment was rather unorthodox. Instead of buying bulky cabinets and tables, we chose to install it all on three Winstead metal frames on wheels. Though unglamourous, this approach was infinitely more flexible. For example with sufficient lead time, we could wheel the entire production system into the Demo Room to record multi-camera presentations (with additional rented cameras).

In summary, the task of equipment selection was approached with the particular demands of the client in mind: portable, flexible, inexpensive, computer-oriented content, field-oriented recording, and edit-oriented switching. This resulted in an integrated video production system that could rapidly and smoothly handle the assignments expected of it.



Videolab Equipment Configuration

2.2.3 Audio Visual Services

Not all the assignments taken by the Videolab are scripted videotapes. Rather, much of the work falls into the category called "AV Services": short-order projects like shooting slides, film-to-tape transfers, slide-to-overhead transfers, "snippets" editing, and prep work for videodisc projects.

2.2.3.1 Commercial Turnaround

DoD holds numerous briefings which require support visuals (slides, overhead transparencies, motion pictures),often requiring a variety of media. This results in the annoying problem known as "mixed media". Briefings with 80 slides and just one overhead transparency. Lectures with videotapes on 3/4" plus VHS and Beta and Videodisc. Demos with 12 video segments, each on a separate cassette. Getting all the visuals organized is difficult and time-consuming. A more efficient approach would be to transfer ALL the visuals to one medium (slides, transparencies, etc.) or edit all the pieces onto just one videocassette.

The cost of making such "simple" changes is generally expensive. Most production houses are set up to do pre-planned, multi-phase, multiple-copy programs requiring days or weeks of advance notice. Thus unplanned, minor-change, single-copy, rush jobs are exceptional. And searching for firms willing to handle such tasks is often a fruitless waste of time. What typically happens is this. The work gets sent out to a regular place with the regular turnaround time, and it returns AFTER the required deadline.

2.2.3.2 In-House AV

The task then was to develop a system capable of completing small audiovisual assignments with a minimum of turnaround time.

Computer Systems Management, Inc. proposed to perform some of the work in-house. But since the Media staff was small and somewhat specialized in video, not all the assignments could be completed in-house. Yet being audiovisual professionals, they had the resources to find the people who COULD complete the work on time.

2.2.3.3 In-House Duplication Plus Extras

The approach taken by CSM was to offer same-day video duplications service, convenient videotape editing, short-order production assistance, and a resource file for locating outside audiovisual services.

Video duplication uses the above-mentioned Videolab editing equipment. Since the equipment was always on stand-by, the Media Staff could provide single-copy same-day service (even same-hour service!) for 3/4"-to-3/4" videocassette duplication. In addition, VHS machines and videodisc players were made available for video transfers.

This same editing equipment was also available for editing "snippet tapes", videotapes of pre-recorded material edited to match the sequence required for a particular briefing (that is, editing segments from 12 tapes onto one videocassette). Though the need for this capability was originally considered secondary, it has become quite popular with the DARPA project managers.

The Media Staff often handles special requests. These include videodisc prep work, map photograpy, CRT shots, shooting slides, Poloroid photography, technical memoranda, and new technology investigation.

The handy audiovisual resource file been used to locate transfer/duplication houses for tape-to-film, film-to-film, hardcopy-to-slide, slide-to-overhead, etc. Audiovisual production houses and equipment rental companies are also included in the file. If the Media Staff cannot handle the job, they can quickly find someone who can.

Using internal and external resources, the Media Staff can accept most short-order audiovisual requests and get them done on time.

2.2.4 The Video Library

The Video Library is a combined effort between CSM's Information Services and the Videolab. It was found that the offices of the project managers were cluttered with stacks of unorganized,undated, unnamed, contractor videotapes. Soon it became impossible to find anything; A central clearinghouse was then considered.

2.2.4.1 The High Cost of Travel

Bringing people in to the office to watch videotapes required travel time and money. It was much cheaper to bring the information to the people. This could be done by sending copies of DARPA demo tapes. But since most of the tapes were "lost" on disorganized desktops, the savings could not be realized. Clearly, the managers needed an organized video library.

2.2.4.2 Send Information to People

The task of organizing a video library boiled down to this: give a descriptive title to each program, list its content and specifications, assign it a catalog number and file it, label each cassette, shelve it according to category, and duplicate and/or distribute it to those needing briefing information.

2.2.4.3 Provide Video Library Service

When a new title is added to the Videotape Library, the Media Staff is responsible for identifying its title, category, specifications, and content description. The Information Staff takes over from there.

They assign the entry a catalog number and make four adhesive labels for each entry. Three go on the videocassette and one goes on a 3x5 card in the library's card file. In addition, the title goes in a category/title binder for quick reference.

When a project manager needs to circulate a tape, the Information Staff mails out the title on loan. If the copy is to be kept permanently by the requestor, the Media Staff makes a duplicate for mailing.

Though the Videotape Library system is not as exciting as the video production operation, it does deserve attention. It reduced the time required to locate a particular title. It standardized content descriptions, which in turn reduced the search time for finding a particular segment within a program. It has saved the program managers time because we, not they, do the labelling and distribution.

It has saved money because we LOAN more copies instead of giving them away (at $25 apiece). And most importantly, the

Videotape Library has enabled program managers to "send the demo tape" instead of flying people in to attend briefings.

2.2.5 Issues

At the end of the first quarter of operation, some "bugs" have begun to appear. This is not unexpected, nor does it render the systems inoperative. Rather, these problems fall into the category of "if we could change things, here's what needs improvement."

2.2.5.1 Streamline Video Services

The level of video production is running at about two tapes a month, as expected. But what is unexpected is that many of these programs are "snippets tapes", not the fully scripted original productions CSM had anticipated. This brings up three issues.

First, scriptwriting is a laborious joint effort between scriptwriter and content expert. Managers are often too busy to assume the role of content expert, so they ask the scriptwriter to find one. Unfortunately, unless an expert is specifically tasked to make a videotape, he feels that this activity is an interruption of his own "more important" work. Thus, he gives it less attention than required to get an effective production.

Second, production deadlines are unrealistic due to the volitary nature of R&D work. It's kind of like a rocket launch in that any one of numerous small problems can scrub the mission, thus delaying the event for months. Not only must the script be written and approved, but shooting cannot begin until the contractor has something to show (and there are always delays in R&D work) and must have time to show it.

These two issues can be handled by having the project manager specifically task a content expert to produce a videotape as one of the project milestones. When the expert is ready to show his results, he calls the Videolab and initiates production. The expert and Videolab set objectives, write the script, and submit it to the project manager for approval. This eliminates the Videolab's problem of serving two masters (and two sets of program objectives and two sets of deadlines and two sets of approvals). This streamlines the production process, quickens turnaround time, and frees the project manager from numerous production meetings and script reviews.

Third, productions often require artwork and props to visualize ideas which cannot be seen in the "real world". (For example, a diagram of a multi-point teleconference system or a flowchart of how a computer processes data.) Unfortunately, these items are the last to get budgeted since they are used once and thrown away. Yet without them, the effectiveness of the videotape suffers.

The production budget problem can be cured by allocating a certain amount of funds per production. ($200 x 50 productions = $10,000, which is low by video production company standards.)

2.2.5.2 Upgrading Videolab Equipment

Although CSM has made some excellent equipment selections, some are real bloopers. The biggest problem is the Time Base Corrector, a device which synchronizes the VTR's with the production switcher. The present TBC has too few correction features; it cannot cope with errors produced by computer-originated video signals. Since much of our work incorporates such signals, a more powerful TBC is imperative.

The rest of the equipment problems are minor. The tripod is too heavy. There aren't enough color monitors. The camera needs a pistol grip. And there's not enough money for videotape stock, maintenance, and odd'n'ends like connectors and adapters.

All these problems can be solved by acquiring the necessary equipment and funds.

2.2.5.3 Enhance In-House AV Service

The Media Staff's expertise is somewhat specialized in the video medium. This has hampered CSM's ability to handle the diversity of assignements given by the sponsor. If we can't handle it, when possible we ship it out. Of course, that is timeconsumi. and expensive and not presently budgetted.

If CSM had transfer equipment in-house, we could reduce the costs and turnaround for film-to-tape work, etc. Perhaps in the future CSM could add an artist/photographer to reduce production costs and project turnaround. Such a person could also help in creating support visuals for briefings and video productions.

2.2.5.4 Not-So-Free Video Library

Although every NEW tape entering the library gets a description and a label, videotapes existing before this service have no labels at all. Temporary library assistance could complete this project (of about 50 tapes) in a week. However, some of the footage is old and the client's content experts would have to help identify it.

In the future, it would be helpful to have a formal sign-out loan procedure. But at present it seems unrealistic for the busy managers to fill out loan slips. Managers sometimes take tapes and never return them. Or they avoid the loan procedure by asking us to send a copy for the borrower to keep.

2.2.6 Summary

The Videolab has been successful as planned in visually communicating those R&D projects where pictures are more descriptive than words. Scripted productions like "Talking Maps", "TACMAPS", and "Kaiser Spyder" are in constant use.

But CSM has found that the Videolab's tools and talents are being used frequently and effectively for capabilities not originally planned. These include the small, short-order jobs in the AV Services category. Media transfers, special production assistance, resource files, tape duplication, and "snippets" editing. Snippets like "Digital Media", "Budget Review", and "Stuck Tanks" have proven to be immensely useful and successful.

Still, managers frequently ask the staff to handle assignments outside their expertise and beyond the limitations of equipment and budget. Perhaps the operation could provide better service if it added more graphic/photographic and media transfer capabilities.

Initial observations indicate that visual communications are helping R&D managers to express their ideas quickly, concisely, and effectively. Most divisions of the Department of Defense have numerous ideas that can be better communicated in pictures than in words. It might be worth their while to consider the savings in time, costs, and worrying, that a Government-Owned, Company-Operated media facility can provide.

3.0 MICROCOMPUTER TECHNOLOGY APPLICATIONS IN C2

3.1 The Hand Held Computer in C2

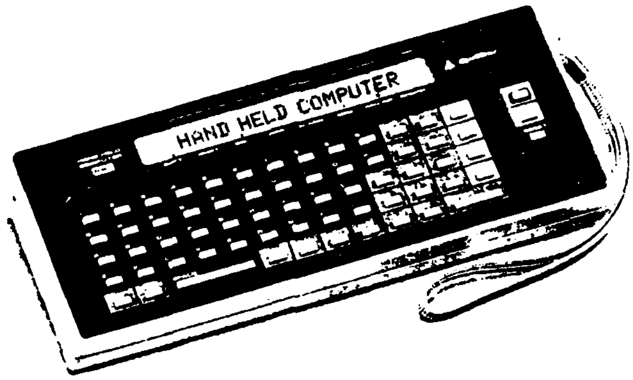
In the past ten years significant advances have been made in computer technology in terms of reduction in size, reduction in power consumption, and reduction in weight. At the same time, there's been a dramatic increase in computational power.

Computer Systems Management has, as one of its ongoing tasks, the role of reporting to DARPA on new research and new commercial products which have possible application to DARPA projects, and to identify innovative concepts and technologies potentially applicable to U.S. national security requirements.

One of the most interesting recent advances in the area of computer applications was the introduction of the Hand-Held Computer (HHC). A variety of companies have introduced "Hand-Held Computers", including Tandy Corporation, Casio, Hewlett-Packard, Panasonic, and Quasar. Where such introductions differ from the programmable calculator (which in an absolute sense is also a "pocket computer") is in the degree of versatility that the pocket computers are capable.

A programming problem may be broken down into the components of : data preparation, input to the computer, computation, control, primary and secondary storage, and output. The new pocket computers have the versatility to provide "control", the interface to new peripherals, and definitions of new operations. The programmable pocket calculators do not have these features. Until now, the calculator user was limited to predefined functions, interfaces, and operations.

We hope to point out possible applications of the new technology and examine the most advanced example of the pocket computer: the QUASAR HHC.



3.1.1 Possible Applications Of The Technology

The portability and exceptionally low cost of hand held computers have broad implications for Defense applications. Possible area of use include all aspects of Command, Control, Communications, and Computation (C4).

One area where decreased size is important is in the augmentation of battlefield communications through improved encryption and decryption of message traffic. Secure communications is vital to any military operation. The current units available to the military are large and unwieldy. Smaller, more powerful computation of encryption, decryption and compression would improve this situation dramatically.

A Hand-Held Computer would permit the encrypted storage of information such as plans, orders, and reports at the unit level. Such encryption would dramatically reduce the possible damage should information fall into enemy hands. Storage of information in an electronic form would also increase the quantity of information available to a field unit.

Portable computation would provide the possibility of providing detailed mapping software to every field unit for the purpose of position calculations. With an internal clock, time and distance calculations become substantially more accurate. When the NAVSTAR positioning satellites are in place, the accuracy will increase dramatically. Current plans for the implementation of LORAN-C positioning could be made portable.

Portable computation would provide the improved speed of processing information by collecting the information in a portable unit for subsequent direct transmission to a centralized database at headquarters. Time is of the essence in battle situations. Up to the minute information on situations and troop positions would provide commanders with improved information on which to base a decision.

The technology already is available to use bar codes and a hand-held computer to provide timely and accurate inventories of equipment. Inventories and inventory management is always a problem in an organization the size of the military. The volume of material used is so great that the current status of inventory condition, placement, and volume is difficult to manage. Automation of the data collection could improve this situation by providing instantaneous information on current inventory status.

Portable computation and communication would make the automated scheduled maintenance of equipment available to the supply personnel and provide them with statistical analyses to predict mean times to failure. Military equipment is becoming steadily more complex, and subsequently more complex to maintain. By having automated checklists for scheduled replacement of parts and by keeping information on maintenance occurrences, required improvements in equipment design may be spotlighted.

A Hand-Held Computer could be used by infantry units to calculate fuel consumption and performance of equipment. By having accurate measurements of fuel consumptions, accurate forecasts may be made for material requirements over specific terrain.

A portable computation device may be mess planning and scheduling of food consumption. "An army travels on its stomach" is as true now as it was then. Accurate mess planning would reduce the cost of waste as well reduce associated transportation costs caused by over-estimation.

Hand-Held Computation would improve the capability of artillery units to calculate and report ballistic and fire control information. Where conventional artillery is still used, pin-point accuracy can become the rule.

Hand-held translators could be used for improving communications in multi-national forces. Since the military can not train every soldier to be a linguist, perhaps a Hand-Held Computer could serve that function.

3.1.2 Characteristics Of The Quasar HHC

In January 1981, QUASAR, a U.S. subsidiary of MATSUSHITA, announced in BYTE magazine the planned production of a Hand-Held computer. Previous announcements had occurred in the October 1980 issue of ASCII, the November 1980 issue of POPULAR SCIENCE, and the December 1980 issue of INTERFACE AGE. The BYTE article, however, was the first article to describe the QUASAR HHC in detail.

After contacting BYTE for further information, CSM contacted QUASAR in Chicago, and Friends-Amis, in San Francisco. Friends-Amis, the developer of the Craig pocket translator, is the software developer for the QUASAR HHC.

CSM selected the QUASAR HHC as the most likely choice for examining the potential uses of hand-held computers for the following reasons:

- The QUASAR HHC uses a standard MOSTEK 6502 microprocessor. This is considered by hardware designers to be an amazing advance, as most pocket calculators have been unable to use standard microprocessors because of the high current drain. Most calculators use CMOS chips that have relatively low power consumption and fewer capabilities. The use of a standard 6502 was achieved by a "power down" circuit, developed by MATSUSHITA, that "turns off" the microprocessor when not in use.

- MATSUSHITA has developed a wide variety of peripherals for the HHC which connect to the main unit through a 44-pin "soft" extensible bus. Peripherals may be connected to the main processing unit without loss of information.

- MATSUSHITA has decided to make the hardware and software specifications of the HHC available to selected developers. The decision was made by MATSUSHITA that the best protection against loss of market position is low cost, extensive support, and a network of third-party software developers.

One of the peripherals available to users will be a ROM burner. One of the more ingenious designs of the QUASAR HHC is the "zero-force insertion" ROM used for program storage. Friends-Amis mounted the ROM in a interesting "cage" that does not permit the ROM to be incorrectly inserted. The ROMs can hold 2,4,8, or 16 Kbytes of program or data. This ROM-burner option will allow users to produce customized software. CSM foresees the day when software will be widely available for pocket computers in such a form.

The QUASAR HHC uses a compact variation of FORTH called SNAP which was developed by Friends-Amis. SNAP is, like FORTH, an RPN threaded interpretive language. Unlike FORTH, however, SNAP is optimized for a microprocessor using a single byte for a "word". The language has no outer interpreter. Interfaces to the user will be through more conventional languages like BASIC. Todd Umeda, of QUASAR, demonstrated to CSM a prototype BASIC developed by MICROSOFT for the HHC.

The 65-key keyboard of the HHC is capable of key redefinition during execution. This feature is extremely powerful, since it permits menu overlays to be tailored to a given application.

The HHC has the feature of an internal real-time clock. Coupled with time-out interrupts on the microprocessor, this feature gives the HHC capabilities not found in many desktop computers.

The HHC uses a 159 x 8 dot addressable liquid-crystal display. Each pixel is capable of being individually addressed. This means that the HHC has the capability of generating its own character sets tailored to an application.

Process control is through a nested set of menus. The philosophy behind the operation of the HHC that was developed by Friends-Amis was that no user should have to know special commands or features. The user should be able to select from a list of possible alternative choices. The menu items scroll past the user at a rate selected by the user and he selects his choice after review of the possibilities.

The HHC has a free-form editor with a "virtual" window that is capable of motion in any of four directions. The keyboard has keys that permit motion in the direction the user wishes to scroll. Since the LCD display is limited to approximately 23 characters, this is a useful feature for previewing data.

Peripheral devices and the keyboard access the processor through an interrupt structure rather than through polling. This feature permits the power-down circuit to turn off the microprocessor until the user touches a key or until a peripheral device requires servicing.

The HHC uses bank selection to access more address space than the 64 Kbytes that the 6502 is restricted to. This is done by "bank switching" the 16 Kbyte blocks that every peripheral is allocated.

A color TV interface 48 x 64 pixel display is available. This is currently the only peripheral that does not have its own internal power supply. The TV adapter requires an AC outlet.

The QUASAR HHC has 2 Kbyte RAM extendible to 4 Kbyte. While this amount of memory does not seem like much compared to most desktop computers, it should be pointed out that this space is fairly substantial by the standards of most hand-held calculators. The HHC is not much larger than most hand-held calculators.

As might be expected for a unit that is to be used for hand-held purposes, the HHC contains a four function calculator.

By far the most useful feature for the HHC is the 110/330 baud modem peripheral. Most of the initial uses will be as a pocket terminal. While QUASAR did not have all the "bugs" out of this peripheral at the time CSM tested the HHC, we were able to access the CSM timeshare facility.

3.1.3 Research Summary

QUASAR seems to have had some difficulty in gearing up for production in the initial release of the HHC product. Some of the initial release dates have slipped. From personal conversations with present and former employees of QUASAR, there appears to be some internal dissention regarding market strategy and hardware design. The initial release of the SNAP language by Friends-Amis was delayed. Most of these difficulties now seem to have been resolved.

In an effort to produce a truly "pocket-sized" computer, a key human engineering factor was ignored, i.e. perceptive size. If a computer is "pocket-sized", then the user expects the unit to be totally self-contained. All functions that the unit is capable of performing should be contained in the unit that is to be carried. If the most common functions require the carrying of a briefcase, then the size of the basic unit and keyboard affects perception of the ease of use. QUASAR seems most interested in size, while from a user standpoint, portability and ease of use are more important. While QUASAR has solved the latter two criteria, they may have overachieved on the former criteria. When a user pays the amount of money that he will have to pay to obtain an HHC, he may want a more substantial package.

CSM's perception is that the product should have a comfortably sized keyboard. Fortunately, the design is so modular that the peripherals may be used with any processor designed to be compatible with the bus structure. It will be interesting to see what the "big brother" of the HHC will be like, when and if it is designed.

The display is somewhat limited. Twenty three characters is frustratingly small for most applications. Todd Umeda, the Product Manager for the QUASAR HHC, indicated that MATSUSHITA may produce a larger display, but that would be for release in late 1982 at the earliest. Again, a larger main unit would resolve this problem.

The available storage of RAM space is somewhat limited. While 2K is large by pocket calculator standards, it is extremely limiting for most computer applications. Again, a larger main unit would permit more battery space and more power for a larger RAM space.

The key problem that worries CSM the most is the lack of a means for large volume storage of information. Possible effort might be considered in determining whether or not it might be possible to develop a bubble cassette interface to the bus structure. Magnetic bubble memory would provide a high data volume, low energy consumption, non-volatile, and physically rugged way of solving this problem.

For military applications, there are several key criteria for performance that will have to be addressed. The bus, while it is very convenient for connecting and disconnecting peripherals quickly, would have to have some form of lock down added that would provide a better more rigid "seal". Such a change in casing is relatively simple and inexpensive.

While the unit passes FCC standards, the unit would have to be examined to make sure that it is sufficiently RF silent to meet military regulations.

The key factor in determining whether or not the HHC becomes a successful product is whether or not the developmental problems are resolved so that software applications may be developed.

CSM is not convinced that FORTH - SNAP is the best means of resolving the problems associated with software development. The threaded, stack oriented, interpretive capabilities of FORTH may be implemented in languages that are more insensitive to programmer error. FORTH is a very easy language in which to write bad code. A common rule for software implementation is that 90% of the cost is associated with the maintenance of an application.

Bad code is difficult to maintain.

FORTH is, by its design, not so much a language as it is an implementation of techniques to extend grammatical and lexical operations. The main advantages to FORTH are the compactness of design and its interpretive nature. These advantages are lost by the manner of implementation of the HHC. There is no "outer interpreter" for SNAP in the HHC. Code development must be performed in an external development system. There is thus no advantage to using FORTH over any language that is capable of generating SNAP compatible code.

3.1.4 Conclusions

All applications of computer technology point to the "Paperless Military" of tomorrow. The Command, Control, Communications, and Computation required of the Military in the next decade will require a speed, accuracy and sophistication that must be planned today.

The key advantages of Hand-Held Computation in improving military preparedness are portability and relatively low cost that would permit individual provision. We don't necessarily see the day when every foot soldier carries a Hand-Held Computer, but we do foresee a future where every soldier carries some form of computational communications capability.

The QUASAR Hand-Held Computer is an exceptional hardware achievement. It shows the implementation of several innovative software techniques. The QUASAR HHC may be somewhat premature in its release. But if the production problems are resolved, there are several military applications that could benefit from this device.

The QUASAR HHC can be a useful tool for investigating the appropriate use of portable computation and communications capabilities to the military. When the QUASAR HHC is released, CSM recommends that research be performed to find new applications for the technology in a military environment.

3.2 The Design and Implementation of an Electronic Notepad

CSM is tasked to perform certain small research projects related to computer science and electronics. Here we detail one of these projects, Telepad: an electronic notepad. Although the concept of electronically simulating paper and pencil is not new, this prototype demonstrated that through state-of-the-art technology, the concept could be inexpensively and commercially reproduced.

Throughout the design and hardware selection period, CSM investigated all commercially available sources to determine what equipment could be best utilized to meet the standards set in the original design. The two most stringent design standards were cost and availability. That is, the cost of the equipment must not exceed $1500 and the list of components must be commercially available to anyone. Of course, the cost of the software would be free to the military as a result of building this prototype.

Furthermore, it was decided that development should not be limited to a single pad but to several units. These should be flexible enough to stand-alone as well as to inter-communicate among themselves. Ideally, in the networking mode, multiple pads could share a common work area. Thus, the current picture could be reviewed and edited by all network users.

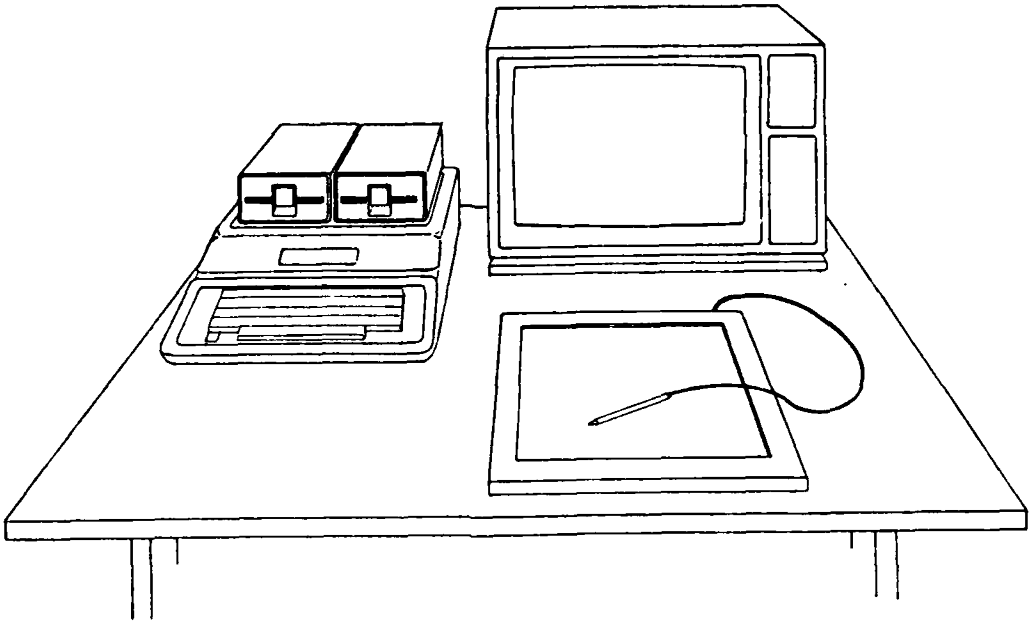
The system was to incorporate various factors of human engineering to ensure ease of operation by the end user. As a part of these operational requirements, the pad was to have a menu which would supply five color options with which to draw and four functions: page forward,page backward, erase, and clear the page. Integral to the system was developing a means of storing and retrieving previously made drawings and notes. This was accomplished by using a mini-floppy disk capable of storing 35 pages of information.

Given these system parameters, the project was developed in three phases. The first phase involved the development of a single stand-alone prototype. Next, results from Phase One would be utilized in developing a four station network. Finally, a networking scheme would be used to institute telephone communication capability between Telepads.

The final hardware configuration included:

- Apple II microprocessor w/48k with a disk operating system
- Kurta Bitpad
- Color TV monitor
- Asynchronous Serial Interface Card - 7710
- Racal-Vadic 2445P/S modem

The above list of hardware components represented efforts to minimize cost and maintain flexibility in compatible hardware acquisition and software control.



Single Station Telepad

3.2.1 Phase One - The First Station

Once the equipment acquisition was completed, the next task became that of organizing the programming team and making program assignments such that the system specifications would be incorporated in line with equipment delivery. The initial phase of the project was to construct several modules which would be integrated by means of a driver routine. This routine would control the main processing and the interrupt structure necessary in the development of the networking phase. Among these modules were such operations as the menu routine, special computation routines for addressing the Apple's hi-res memory area and Kurta data conversions, compression routines, and plotting routines.

3.2.1.1 Data Acquisition

The initial task was to generate compatible data which amounted to the actual interfacing of the Kurta bit pad with the Apple. The problem involved converting the eleven-bit information stream, which the Kurta produces, into a coordinate pair which the 8 bit microprocessor could handle. By incorporating a simple scaling process the initial interfacing of these two critical hardware components was improved. The completion of this interfacing encompassed yet another calculation. Due to the internal addressing scheme of the Apple hi-res screen area, neither straight sequencial line scanning nor direct plotting of data could be implemented. Consequently, the coordinates, which had already been scaled, had to undergo a subsequent calculation to determine the exact pixel location for all information appearing on the screen. Later, the routines which were written to accomplish this task would be invaluable in the areas of menu selection and data compression.

3.2.1.2 Compression

Two very important areas of concern were the ability to draw on the screen in high resolution and still save 35 pages on disk. First, the screen is capable of displaying a maximum of 8k bytes of information. Second, due to hardware limitations, the mini-floppy disk is only capable of storing 4k bytes of information per track. Obviously, there is a direct conflict with the two characteristics. Therefore, compression schemes were tested and retested for practicality and effectiveness.

Two such schemes were attempted. The first scheme for this graphical data compression was a block coding technique. This technique split the picture into 1536 4 X 8 pixel blocks which assume a resolution of 256 X 192. Each block was then scanned and given either a code of Ø if it contains only the background color, or a code of 1 which in turn caused a division of the larger 4 X 8 block into four smaller 4 x 4 blocks each of which was then scanned for data. The block was given either a 1Ø code for no data or a 11 code to indicate that data exists in this block. Subsequently, the 11 code dictated that the next 48 bits of information would be stored as actual picture data. Using this technique an 8k picture was easily reduced to the 4k limit. However efficient this method, it did not meet a required .5 second retrieval time. To achieve this quick refresh time a second method of linear compression was tested. Although considerably more simplistic, this method was very effective. Linear compression techniques tried to find repetitive datum and store the data value and repetition counts. This technique (when coupled with another a routine which calculates the appropriate line on which to reproduce the data) proved to be much faster than the block coding scheme and still retained the required compression factor.

Both compression schemes generated problems. For instance, the linear scheme was not capable of saving certain types of pictures within the track per picture framework which afforded a maximum 35 pages of information. In particular, a screen with a host of vertical lines could not be adequately compressed. As for the block coding scheme, it could not reproduce the picture fast enough for the system requirements. Also, there were times when the compressed data overflowed the 4k storage buffer area. This problem required that both compression schemes had to incorporate a routine to check for the end of buffer area. This meant that compression had to be a continuous function which involved error message-handling and byte-counting both of which would prohibitively slow the plotting function. On the other hand, without checking for the end of storage, at least part of the screen could be lost.

Although the linear scheme reproduced 80% of any picture consistently, this was totally unacceptable. Therefore, after development and implementation of the two compression schemes, the decision was made to save only 17 pages of information per disk where each page requires two 4k tracks per picture and saves the original screen data. However, these compression schemes were utilized until the last phase of the project when the end-of-buffer checking problem was fully appreciated.

3.2.1.3 The Menu

The approach used in the menu design was to provide a user-oriented menu to permit the option of 5 colors and to provide the following functions:

F - Forward page

B - Back page

E - Proximity erase

C - Clear current page

P - Print on hardcopy

The selection of functions and colors incorporated a toggle switching approach. Also, the menu checked for whether the current page was either the first page, (page one, in which case the "B" back option disappeared from the menu), or the last page,(page seventeen, in which case the "F" forward option disappeared).

The operation required in making a menu selection is determined by a "pen down" condition on one of the menu boxes located on the rightmost area of the screen. This point on the screen correlates to an area of the Apple's hi-res memory. The determination of which menu option is being selected is a function of the blinking, non-destructive, proximity cursor. When the pen is depressed on the menu option, a coordinate pair is returned to the program. This coordinate pair is set such that if the pen is down in the menu area the x coordinate becomes the menu flag and the y coordinate becomes the offset to a lookup table in the menu routine. This then sets the color or function.

The menu options have other functional user-oriented features. For example, the menu options do not affect the pen parameters with the exception of the color options and the proximity erase. The erase option is somewhat unique in that it may be toggled off by selecting a color or by re-selecting the erase option (which puts the pen back to the color being used prior to the selection). Should the user select a paging option or the clear page option, the pen setting is maintained on the current page.

3.2.2 Phase Two - Networking

The major focal point of this development phase was the transformation of the single-station notepad into a network capable multi-pad system. Although the single station telepad was prototyped to be compatible with the multistation version, there were still several areas of concern. These concerns related to the simultaneous drawing requirement and to the Apple's disk operating system which is utilized to save each page of information. The drawing requirement necessitated the full utilization of the 6502 interrupt structure in conjunction with the 7710 asynchronous serial interface card and a software-controlled data transmission technique.

An equally involved development problem concerned the disk operating system. By incorporating the system furnished routine, certain constraints mandated that there could be no interrupts without a fatal system error. Of course, this was not a problem in the stand-alone prototype and in fact the stand alone version did not require any interrupt processing.

3.2.2.1 Data Transmission

In order to network four Telepads in a ring configuration, it became necessary to develop a scheme to reduce the stream of information being passed over the RS-232 line. There needed to be a method of telling which Telepad was generating the information. The Apple also needed to know the color of the point being plotted or which option had been selected. Finally, it needed to know how many bytes of information were being transmitted.

The solution was to generate a tag byte for each transmission. In order to store all this information in one byte, a bit pattern was established to indicate information about the byte or bytes which followed. The following graphic description shows the bit pattern used in the tag byte.

7	6	5	4	3	2	1	Ø

BIT NO.	FUNCTION
Ø-1	Holds station number
2	Not used; may be to incorporate more stations at a later date
3	Dictates whether one or two bytes follow tag
4-7	Values in this nibble range from 8-15(F) which decsribe the following: 8 - Plot green 12(C) - Plot blue 9 - Plot white 13(D) - Erase option 1Ø(A) - Plot orange 14(E) - Not used

This method permits the compression of the necessary information concerning the characteristics of the point to be plotted or the options to be selected. Also, the technique permits a reduction of the subsequent data by giving the interrupt handling routines the exact number of bytes being transmitted. This is important. To further reduce the flow of information over the communication lines, a delta type of compression routine needed to be incorporated to send the plotting information.

Initially the interrupt handling routine receives a three-byte transmission which consists of the tag, x-coordinate, and y-coordinate. These x and y values become the reference point for the next transmission. Now, only one of two conditions (either another three byte transmission or a two byte delta transmission) will occur. In both cases the tag byte is the first byte to be transmitted. It indicates the type and number of bytes to follow.

If the delta byte condition occurs, then a line connecting routine is used to plot the line between the old x and y coordinate to a new positioning of the x and y coordinate determined by the magnitude of the high and low nibble of the delta byte. Each nibble holds the change in x and the change in y, respectively. By limiting to seven pixels the maximum change in either direction, the high bit in each nibble then indicates whether the change is positive or negative. Thus, the high bit is set when the change is in a negative direction, or it is not set when the change is in a positive direction.

3.2.2.2 Buffering

In order to accommodate a smooth transmission of data, the interrupt structure of the 6502 microprocessor and a dual buffering strategy were needed. This buffering scheme needs some explanation.

The data generated by two or more Telepads required varying processing time which was dependent upon the number of stations transmitting data. This in turn required interrupt processing. Thus with normal processing being interrupted and data being generated simultaneously, the network needed two FIFO temporary storage areas. The need to allocate a large area of memory was greatly reduces by using a wrap-around buffer. These buffers were utilized to fulfill the simultaneous drawing requirement which required the implementation of the interrupt processing.

3.2.2.3 Interrupts

There are two types of interrupts which permit the handling of data for the inter-communication of Telepads. Each interrupt, receive and transmit, is processed in the interrupt handler routine. However, transmit interrupts can also be generated in the main driver routine. Interrupts are activated whenever there is data to be sent or received (ie. there is data in one of the buffers) and whenever the asynchronous serial interface card is ready to send or receive data. The processor knows when the serial interface card is ready by testing the status registers of the card. When a pen is put to the bitpad and when there are multiple pads in the network, the data generated by the originating station is processed in one of two ways. If the status register indicates that there are no interrupts in progress, the data is sent around the ring as soon as it is generated. Conversely, if the status register indicates there is an interrupt in progress the data is placed in the transmit buffer until the card is ready. In any case, whether a receive or transmit operation is in progress, only one byte of information is actually sent or received. Processing of the originating pad is continued until the serial interface card is ready to move data. Of course, should more data be processed to be transmitted or received from other pads while an interrupt is in progress, the data is then stored in the transmit or receive buffers at the originating or receiving stations, respectively.

When and interrupt occurs, the first piece of data to be communicated is always the tag byte. A simple test is performed to determine how many bytes are being communicated. Then, the appropriate flags are set so that the data from one source is always conveyed before data from another source begins. The essence of the utilization of the interrupt structure is to permit the optimization of available processing time within the constraints of the 65Ø2 microprocessor.

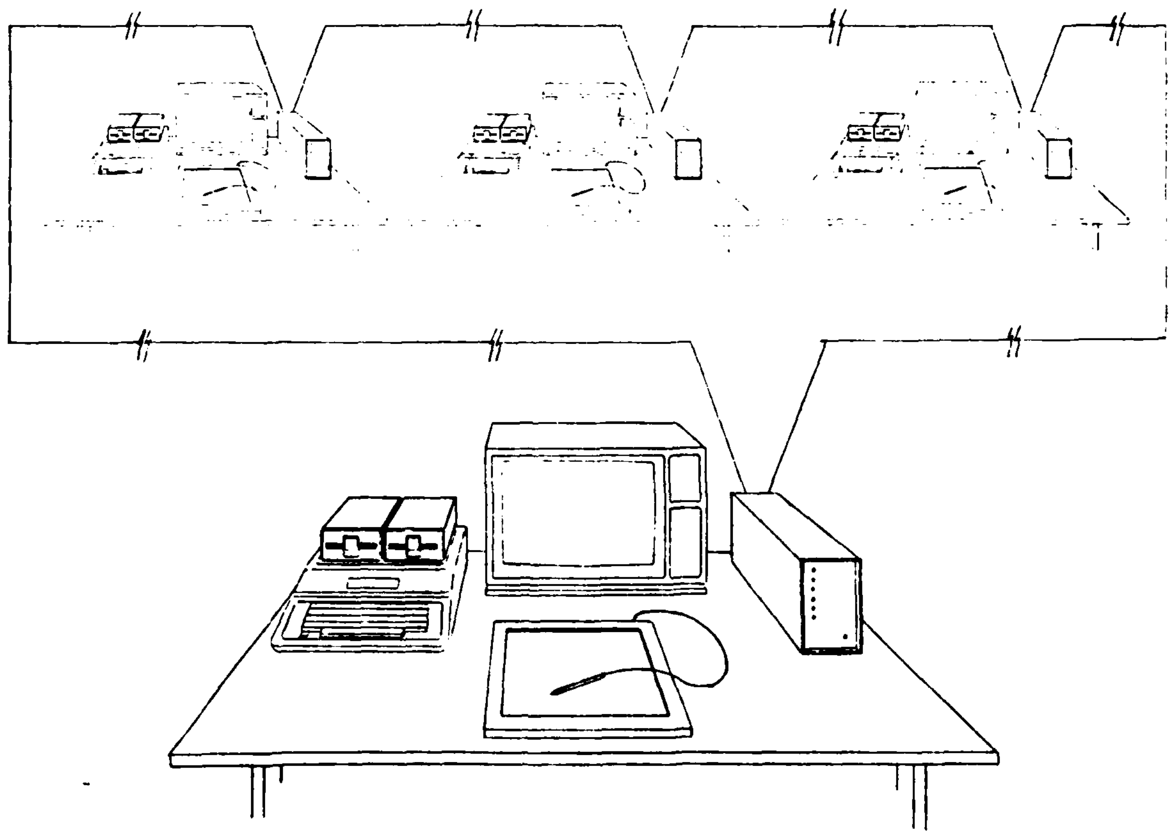
3.2.3 Phase Three - Telephone Communications

With the interrupt structure of the 65Ø2 and the buffering techniques fully implemented, the final phase of Telepad was to utilize standard telephone lines and modems in transmitting the information around the ring of Telepad users. Although alternate types of transmission media (such as dedicated lines and 96ØØ baud, full duplex modems) were considered, the costs of such equipment defeated the entire thrust of the project. Hence, the cost limitations of the project led to the investigation of several modems and to the acquisition of two Racal-Vadic modems per station. These modems were selected for two essential qualities,low cost and a reverse channel capability.

The reverse channel capability was the critical factor. The modems had to be capable of supporting the handshaking between stations. Although the reverse channel transmits at a slower rate than the normal transmit channel, this channel is essential to informing the adjacent transmitting pad in the ring that an uninterruptable operation is being conducted. Clearly, this handshaking prevents a fatal system error when the disk operating system processes requests for storing and retrieving information. Basically, the handshaking is a process which sets the reverse-channel enable line low when the minifloppy disk is being accessed. It also precludes the transmission from the adjacent pad in the ring. During this intentional interruption, the data is stored in the transmit buffer of the adjacent pad. It is subsequently sent on around the ring after the disk access is completed and the handshaking line is restored to original high setting. Also of some consequence, is that a short wait (approximately 10 milliseconds) had to be incorporated in order to allow time for the receive data line to regain its original status and to allow time to transmit it over the reverse channel.

There are two reasons why two modems are required. The ring network is essentially comprised of up to four stations, each with its own transmit data line and receive data line. Thus, with two types of data coming over the data lines (the modems being only half duplex), one modem is needed for transmission and another for reception. Since the modems operate in separate, yet similar roles over the same RS-232 port, an important 'Y' type wiring is implemented to affect this technique.

The final adjustment in interfacing the modems for telephone transmission of Telepad data involved characteristics of the hardware used. The modems are synchronous modems and, consequently, equipped with their own clocking devices. Thus, in order to facilitate a 2400 baud transfer, the serial interface card had to be adjusted to accept the modem's clock instead of its own clock. In making this adjustment, the serial interface card was changed from asynchronous to synchronous and is dependent on the internal clock of the modem.



Four Station Telepad

3.2.4 SUMMARY

The initial research requirement of the project, which was to prototype an electronic version of the common notepad, has been completed. The original cost parameters were slightly relaxed to approximately $4,000 to accommodate praticality and timeliness in completion of the project. Nevertheless, many available hardware products were ignored in order to finish within the already expanded cost limitations. An example is the low resolution of the screen which is a direct reflection of a limitation of the microprocessor architecture used in the development. However, by fully utilizing commercially available equipment and incorporating techniques such as data buffering and interrupt processing, the effort to reproduce the "shared" electronic notepad has been successful.

The software was designed to give the user both comfort and confidence in using the pad as an everyday tool in the office or at home. With features such as the removable storage medium, color options, and toggle switching of menu items, the pad offers both human engineering and practicality. Thus through careful hardware selection and software design, CSM has proved that the inexpensive electronic notepad is accessible in terms of cost and current technology.

4.0 CONCLUSION

Video technology has inherent to it's nature, the tremendous capability to communicate. The communication can take the form of visual arts, briefings, data storage and retrieval, and training through the ability to blend pictures with sound. The videodisc revolution will advance video technology to a new plateau. These advances in conjunction with the AV services provided in the newly established VIDEOLAB will enhance the capability and productivity of both the contractor and sponsor alike. The costs savings on the GFE equipment will be realized in a brief period through reduced travel expenditures and the advantage of in-house support.

The exploding technological revolution in microcomputers must be monitored on a daily basis. Developments such as the Hand-Held Computer could have great impact upon current C2 applications. This report demonstrates some of the potential as well as some obvious product shortcommings. The electronic notepad prototype (TELEPAD) has proved to be a relatively inexpensive adaptation of off-the-shelf hardware with software designed to meet the needs of the research and operations community. TELEPAD is now ready to be transferred to operational use.

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