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MOVING OPTICAL TECHNOLOGY
IN-HOUSE

by

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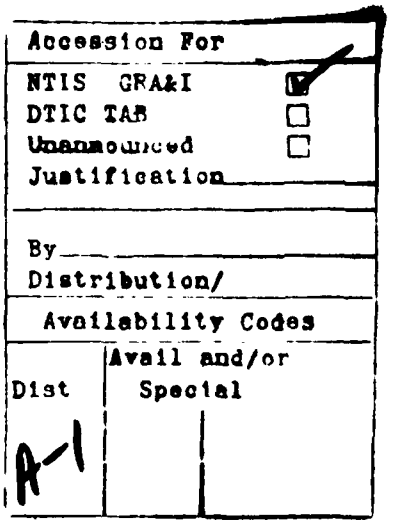
ABSTRACT

The Navy, through a series of projects and programs, is identifying a considerable number of uses for optical technology. Key commands and Navy projects using optical technology are identified and reviewed. Currently, the Navy has no production capability for this medium nor does an optical production facility exist for classified data. The issue is whether the Navy should develop an optical technology production facility to avoid the use of outside contractors. This research looks at current costs for producing CD-ROM and what cost savings might be incurred through the in-house use of this technology. And if the technology were developed internally, questions such as who should manage this program and how should it be managed need to be addressed. The impact and benefits and barriers to developing an optical technology in-house capability in the Navy are summarized.



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I. INTRODUCTION

A. GENERAL

Optical technology has developed rapidly. Navy commands are recognizing its potential for solving information storage and retrieval problems. What if you were told that you could dramatically reduce the time it takes to find information. That within seconds you could have in front of you a chapter from a technical manual describing the tear down procedures for a gas turbine engine, or last months operating logs for your distilling plant, or the message you received six months ago that is referenced in a message received today! If you ever had to wade through a stack of microfiche looking for the most current stock number of a supply part, you would realize the benefit of reducing that time to just 30 seconds. The solutions to these problems may be the use of optical technology.

Optical technology involves three different phases: Recovery of data prior to placing it on an optical storage device, actually storing data on optical storage media devices themselves, and retrieval of data from optical media. This research concentrates on a particular storage media Compact Disk-Read Only Memory (CD-ROM). Data storage using CD-ROM requires an involved manufacturing process using laser technology. Write Once Read Many (WORM) optical disks allow

the user to store information directly on the disk. Optical technology is growing at a rapid rate in private industry as well as in the government sector. The ability to store and retrieve over 270,000 pages of material contained on one 5 1/4 inch compact disk presents tremendous possibilities for the end-user to be more productive, efficient and innovative. If used to its' full potential, CD-ROM can significantly reduce reliance on paper and save space and time. CD-ROM provides a viable alternative to conventional methods of maintaining technical publications, instructions, forms, and records. A number of projects and programs have used CD-ROM and there is a growing interest in increasing its use throughout the Navy. In the past two years production costs for optical technology have dropped dramatically making it more appealing.

The process for producing a CD-ROM disk can be broken down into three stages: Pre-mastering, Mastering, and Duplication. Included in the Pre-mastering stage is the structuring of files, indexing, application testing, insertion of the error correction and detection coding, and storing the data on computer magnetic tape. Pre-mastering can be done completely by the user which brings down the overall cost of the production process significantly.

Pre-mastering requires the purchase of additional hardware. There are several different simulators on the market, which all have the same basic features. They have a large capacity hard disk and a 1/2 inch 9-track tape drive.

The user transfers raw data from a computer readable form which is either a 9-track tape, floppy disk or hard disk onto the simulator hard disk. The data is scanned, edited and indexed into a desired structure. These files can be previewed to ensure the data is presented in the desired form and checked for errors one last time. Then the information is transferred to a 9-track tape.

The mastering phase consists of taking the pre-mastered magnetic tapes and converting them to a glass master disk. This must currently be accomplished by one of several commercial vendors with mastering equipment. Duplicates can be made from this glass master. A thesis by LCDR David J. Lind titled "Optical Laser Technology, Specifically CD-ROM, and Its Application to the Storage and Retrieval of Information" dated June 1987 provides detailed information on the production process of optical technologies.

The duplication phase consists of stamping out copies of the glass master disk to blank CD-ROM disks.

B. OBJECTIVE

CD-ROM is a key element in moving the Navy toward a paperless ship. Its use will change the way we access, retrieve, store, process and conceive information. In order to fully support the fleet with timely updates, the question is whether an in-house production capability should be developed. The Navy has no capability to produce CD-ROM and

must rely, in part, on private industry. Without an in-house optical production capability the Navy will remain dependent on vendor support. The vendor controls the cost of production and shortened delivery times increase that production cost. Private companies who recognize the benefits and applications of CD-ROM are developing their own CD-ROM production facilities. A major objective of this thesis is to determine if the Navy should develop an in-house production capability for optical storage technology.

C. RESEARCH METHODOLOGY

The methodology involved in this research began with a literature review of magazines, periodicals and books. Most of this literature was strictly background information used to gain an understanding of the technology. This effort coincided with phone interviews with Navy commands and government agencies which are becoming involved with optical technology. This led to contacts with private industry enabling me to determine current costs of producing CD-ROM. Additional literature was obtained, as a result of these phone interviews, which focused on the issues of this thesis. This information was analyzed to determine the feasibility of developing an in-house production capability focusing on cost-benefit savings, need, and funding. Observations and recommendations for the future development of optical technology have been made based upon this analysis. It became

apparent, early in the research, that information would be fragmented and that many of those interviewed would not possess written documentation to back up their information. Lack of printed information emphasizes the need for more coordination among different Navy commands in developing optical technology capabilities. No funding for travel or sponsorship for this research was sought.

II. CURRENT AND POTENTIAL OPTICAL TECHNOLOGY USES

"There are currently over 100,000 CD-ROM readers country wide in use in 1988 and that number is expected to double in the next year." [Ref. 1] Many different agencies and companies are starting to realize the tremendous potential of CD-ROM as a storage/access medium.

Several products containing logistic data have been developed by industry to provide the military services with a quick retrieval system for supply support using CD-ROM. Among these products are "Haystack," published by Ziff Communications company containing logistic data for DOD, "Navlog," published by Optical Publishing Inc. containing navy logistic data and "Parts-Master," published by the National Standards Association containing eleven files of DOD and service specific logistic information. These are available for lease at an average price of $5,000.00 per year. These products used Defense Department logistic databases which were stored on microfiche and converted them to CD-ROM. These products added application menus and access methods to that data. They proved to be a great improvement over microfiche and rapidly gained popularity.

CD-ROM use is also growing by tremendous leaps and bounds in the private sector. Just three years ago, only 20 CD-ROM applications had been produced, mostly by service bureaus.

"Today, there are more than 800 CD ROM titles and more than 70% were developed in-house." [Ref. 2] By the end of 1988, research firms predicted that over 1.1 million CD-ROMs would be distributed.

The Defense Logistics Agency (DLA) is responsible for publishing and distributing the Defense Department's logistics databases quarterly on microfiche. DLA converted these logistic databases from microfiche to CD-ROM because of cost and functionality advantages. The Defense Logistics Support Center (DLSC), a subsidiary of DLA, joined the Navy Supply Systems Command (NAVSUP), in 1987, to develop this capability. This project was named the Federal Logistics Data on Compact Disc Program (FEDLOG). FEDLOG is composed of the following logistics databases: Navy Master Data List, Master Repairable Item List, Federal Supply Classifications, Commercial and Government Entity File, Federal Item Name Director, Interchangeability and Substitutability List, Items Requiring Special Handling, Navy Item Control Number Cross Reference List, Master Repairable Item List, and Identification List. FEDLOG is in a prototype stage and is being distributed quarterly on 3 CD-ROM disks to 24 naval shore activities and 25 ships.

One of the strengths of this prototype is that user recommendations are being incorporated as soon as possible to improve the product's features. Most of the reviews have been very favorable, resulting in some Navy commands canceling

their subscription of the commercially available products. Feedback from fleet units have reported a 60-70% time savings in access and retrieval of information using FEDLOG over microfiche.

In October 1988, private industry requested the Defense Department and Congress to investigate the procurement procedures used with FEDLOG. FEDLOG was thought to be in direct competition with private industry to provide information and services. This resulted in a review of FEDLOG by the General Accounting Office. In March 1989, the Office of the Secretary of Defense (OSD) determined that FEDLOG was not competing with private industry. DLA is hoping to put out a Request for Proposal by June 1989, for production of a revised FEDLOG disk, with plans to distribute Navy-wide by DECEMBER 1989.

In March 1988, a SPAWARS project called "Target of Opportunity Paperless Ship" (TOPS), provided five ships (BELLA WOOD, RENTZ, HALSEY, IOWA, and LEYTE GULF) with a work station. The hardware consists of a laser printer, optical scanner, Write Once Read Many (WORM) drive, and two CD-ROM drives. These ships have been provided with FEDLOG and are currently experimenting with this new system. They have been scanning paper documents and technical manuals and storing them on WORM disks. The USS HALSEY has stored the equivalent of 300 square feet of documents on WORM disks and have had no trouble using the system for access and retrieval of the

information. The Navy is now determining if the hard copy documents can be removed from the ship permanently.

A future development for ships with Shipboard Non-Tactical Automated Data Processing (SNAP) versions I/II and FEDLOG is being researched by the Navy Management Systems Support Office (NAVMASSO). They are trying to develop SNAP II's capability to automatically search the FEDLOG disks for technical editing of requisitions. This is currently being performed by the user to check the price, unit of issue, and other data on the requisition for correctness. Automating this function will represent another significant time savings for the supply storekeepers. SPAWARS' current desires are to have similar work stations placed on all ships of the fleet by the end of 1989.

With improvements in scanner technology a technical manual can be scanned onto a WORM disk or tape and transferred to CD-ROM disk. Once on CD-ROM the disks can be replicated and mass distributed to users. This provides all kinds of possibilities for moving the fleet to the "Paperless Ship" concept. Ships' publications, forms, engineering logs, equipment operating logs, ship's deck log, and message files can all be retained on just a few CD-ROM disks. Not only would a space savings be realized but an individual's productivity in being able to access more information in a shorter period would be increased. Time, money, and manpower

are all becoming more precious as the Navy budget tightens. CD-ROM presents a viable alternative to cutting costs.

The following is a brief list of some completed and proposed Navy and government projects in addition to those already mentioned.

- NAVSUP has placed the Hazardous Material Information System (HMIS) on CD-ROM.
- Naval Sea Systems Command (NAVSEASYSCOM) is conducting a Trident Submarine Project--to automate all records maintained in a Fleet Ballistic Submarine (SSBN) engineering log room using optical technology.
- Naval Oceanographic Research Development Agency (NORDA) is taking Defense Mapping Agency data and formatting it, placing it on CD-ROM and then converting it to WORM to be used in aircraft.
- Naval Air Development Center is evaluating CD-ROM players in different environments such as high heat, and altitude to determine their adaptability to aircraft environments.
- Navy Publications and Publishing (NPPS) is researching the feasibility of placing many printed government forms on CD-ROM.
- National Oceanographic and Atmosphere Administration (NOAA) is starting to store charts and mapping data on CD-ROM.
- National Aeronautics and Space Administration (NASA) is exploring the conversion of planetary observation data from tape to CD-ROM.
- Department of Energy (DOE) is exploring converting their depository library files from microfiche to CD-ROM.
- Naval Postgraduate School (NPS) Monterey has completed several research projects on optical technology. Including:
    - Producing a CD-ROM from the Transaction Ledger on Disc, at the Naval Supply Center in Oakland, California.

- Research in using optical media to collect in-coming message traffic and access the messages using hypertext.

- Exploring the ability to access optical device including CD-ROM from various Local Area Network (LAN) environments.

- A project to use optical technology in the Naval Postgraduate School Library is in progress to store some of its thousands of theses and technical documents on WORM to enhance library operations and conserve space.

III. BARRIERS AND BENEFITS TO DEVELOPING OPTICAL TECHNOLOGY IN-HOUSE

Developing an in-house capability faces a number of issues which must be considered and weighed against future benefits. Eight barriers were identified that are impeding progress toward this objective.

A. BARRIERS TO IN-HOUSE PRODUCTION

1. Cost

With given resources and Navy priorities, there is currently little funding being provided for development of this new technology. The overriding drawback to developing an in-house production facility continues to be the shrinking Defense budget. Current estimates for developing an optical medium production facility are approximately four million dollars. That price has been dropping in the past two years. However, price estimates stop there and do not address the costs of operations, maintenance, and personnel to operate such a facility.

2. Competition Among Programs

Funding for development of an in-house capability would come out of the same budget that is being used to upgrade the SNAP installations in the fleet. Given the decision of installing a SNAP installation or a paperless ship

work station the end-user seems to prefer the upgrading of the SNAP System with which he is more familiar.

3. Player Base

One of the major reasons for not pursuing a production capability is that current usage, knowledge, and demand for CD-ROM is too low. There are not enough CD-ROM players distributed throughout the Navy. The Navy supply system does not have the players in stock yet, so all units must purchase players from commercial sources. A companion contract for the Zenith Z-248 computers which is planned to be awarded this summer should make CD-ROM players available Navy wide. Despite proven time savings, some commands cannot afford to spend the $1,500.00 to obtain two CD-ROM players because of budget constraints. Because of this, the user base is growing slowly, keeping the demand down for more CD-ROM products. Even if the drives existed, there are not many products available to help specific shipboard functions.

4. Fragmentation

Optical technology progress within government environments has been fragmented and individual agencies have pursued optical technology independently. Projects have been isolated with the exception of FEDLOG, and the Navy as a whole is still in the discovery stages. Several different commands including NAVSUP, NPS, NAVSEA, NPPS and SPAWARS, have individually experimented and studied the possibilities of using CD-ROM. These efforts have not been coordinated at a

higher level. Information has been disseminated within these commands but not among all system commands and field activities. This has led to an overall lack of shared information, and knowledge.

5. Commercial Competition

SPAWAR'S "TOPS" project is currently on hold as private companies have appealed to Congress to investigate the program's selection of hardware. The complaint is that the Navy did not competitively bid the contract and is going against provisions of the Brooks Bill, which created competition in government contracts. This delays the distribution of optical equipment and software to shipboard personnel.

6. System Design for a Broad Base of Users

Producing a system which will be used by many different users with many different requirements and views of the data, may require very sophisticated software. Software to serve many different agencies with varying formats has not been developed.

7. New Technology State of Art

Private industry is continuing to make advances in optical technology. Fast growth and lack of standards within this technology has made commands leery of committing to a technology where something better may be just around the corner. For example, the work going on to develop a truly interactive or "writable" CD-ROM disk similar to the magnetic

optical disk currently available could change the Navy's use of WORM. It is believed that this interactive CD-ROM will be introduced before the end of this year.

8. Lack of Management Commitment

The "PAPERLESS SHIP" concept was strongly supported by Vice Admiral Metcalf prior to retirement. His retirement, combined with the tough budget cut decisions facing top Navy management levels reduced enthusiasm for this program.

B. BENEFITS OF DEVELOPING AN IN-HOUSE PRODUCTION FACILITY

Despite the barriers presented, CD-ROM production offers some distinct benefits which increase in value as more CD-ROM are produced and distributed to the user.

1. Cost

One of the most favorable aspects of using CD-ROM technology is that the cost to produce information on this medium is inexpensive.

The prices vary for pre-mastering from vendor to vendor. Table 1 describes a sample price list.

As discussed in Chapter I, users with the purchase of a pre-mastering work station are capable of completing this stage of the production process. The average cost for a pre-mastering work station is about $40,000.

Mastering fees vary from $1,500 to $5,000 per master, but a trend shows the cost to be dropping. Duplication of the

TABLE 1

ESTIMATED INDUSTRY PRICING [Ref. 3]

CUSTOM APPLICATIONS:	
Application Definition	$95.00/Hour
Application Programming	$75.00/Hour
DATA CONVERSION:	
Analysis & Programming	$75.00/Hour
Processing	$1,500 Plus $25.00/MB
INDEX SERVICES:	
Data Base Layout	$1,500
Key Index Build	$1,500 Plus $75/1000 Keys
Design per hr.	$95.00

glass master normally runs between $2.00 to $2.50 per disk. Overall, if the user does the pre-mastering himself, he can have 100 CD-ROM disks produced for as little as $1,700.

a. CD-ROM vs. Magnetic Tape

Dramatic cost savings can be realized in using CD-ROM over magnetic tape storage, particularly when dissemination of massive amounts of data is desired. The National Aeronautics and Space Administration's (NASA) "Voyage to the Outer Planets" project was produced in a set of three CD-ROM disks. Approximately 6,500 high resolution images were

stored on each disk. This is equivalent to 6 gigabytes of data, which would require 270 nine-track 1600 bits per inch (bpi) magnetic tapes. Based on a figure of $30.00 per tape, the cost for the storage of this image database is $8,100.00. The three CD-ROM disk set cost $21.00 to store. Distribution costs to send a small disk, as compared to 50 pounds of publications is a large cost savings in itself. To mail a CD-ROM would cost approximately 75 cents, to mail an equivalent amount of paper (270,000 pages) would cost approximately $4,136.00, and to mail 270 magnetic tapes would cost approximately $620.00.

When discussing the cost savings involved in using CD-ROM, one of the most dramatic savings margins is documented in a June 1988 study done by Association of Research Libraries (ARL) in comparing the cost of CD-ROM to that of producing microfiche. Several projects from different agencies are fully documented and show not only the realized savings but some of the diverse applications for CD-ROM. The three projects summarized below show the versatility of CD-ROM. One project is a CD-ROM containing statistical data, a second with descriptive data in a record format, and the third containing full text format data.

b. CD-ROM vs. Paper

The first project is from the Census Bureau. The Census Bureau collects and disseminates information that is used by many kinds of organizations. Much of this information

is not easily retrievable by individuals because much of it is normally stored on magnetic tape. In 1987, the Census Bureau became the first Federal agency to publish and distribute data in CD-ROM format. The initial test on a small number of depository libraries was so successful that the Census Bureau decided to increase its' use of CD-ROM. In March 1988, the Census Bureau mastered a disk containing the 1982 Census of Retail Trade by zip code and the 1982 Census of Agriculture data. The project distributed a CD-ROM, the software, and hard copy documentation. The printing costs alone, not including distribution for the Census of Agriculture was $75,960.00. The cost for electronic dissemination in CD-ROM format was $13,691.00.

c. CD-ROM vs. Microfiche

The second project involved the distribution of the Toxic Release Inventory (TRI) in CD-ROM format to 400 libraries by the Environmental Protection Agency (EPA). The total cost for this project using CD-ROM, including materials, fees, postage, and labor was estimated at $22,319. Most of this amount, $20,000, purchased software licenses to allow use of contractor developed software. Costs for the software licenses will vary a great deal depending on the vendor, product, and the number of disk copies produced. The figure used in this project was $50 per disk copy. The license fee includes the cost of the floppy disk and documentation to support the software.

- Cost for microfiche distribution $70,257.00
- Cost for CD-ROM format dissemination $22,319.00

The third project, comparing the cost savings of CD-ROM over microfiche, estimated the cost to publish the Congressional Record on CD-ROM. The Congressional Record was published in three formats: Paper, microfiche and nine-track magnetic tape. In 1986, because of budget cuts, distribution of paper was stopped and only microfiche was used for distribution. The following is a cost comparison for 1,305 depository libraries for a single session of Congress, produced and distributed in microfiche and cost compared for CD-ROM formats but not actually produced or distributed. The CD-ROM format provided much greater research capability and at a significant cost savings as shown in Table 2.

These examples demonstrate the tremendous savings that can be realized with CD-ROM. Regardless of the format, full text, statistical data, or descriptive data, use of CD-ROM produces cost savings over paper, microfiche and nine-track tape. The savings are not only realized in the basic cost of production but also in quicker access to the information and reduced storage requirements. The key to quick retrieval is the indexing of the data. The main characteristic of projects where CD-ROM production and distribution are cost effective is the size of the database where the information does not change rapidly. In every

TABLE 2

ESTIMATED COST COMPARISONS FOR 1,305 DEPOSITORY LIBRARIES FOR ONE YEAR [Ref. 4]

	MICROFICHE	CD-ROM
Printing Costs		
Record Text	$ 0	$ 0
Record Index	39,542	39,542
Production Costs		
Master Copy	5,048	1,700
Duplicate Copies		
Fiche	36,892	0
CD-ROM	0	2,610
Floppy disk	0	6,525
Postage		
Record Text	1,109	1,945
Record Index	4,085	4,085
Handling		
Record Text	71,123	78
Record Index	404	404
Documentation	0	653
Total	$158,203	$57,542

project reviewed, a large database and a large distribution base produces cost savings by using CD-ROM.

d. CD-ROM vs. WORM

Defense Mapping Agency (DMA) demonstrated an exception to the favorable cost savings realized by CD-ROM.

They conducted a cost effectiveness comparison study of CD-ROM and WORM optical disk drives. The study analyzed the total cost comparisons for CD-ROM, and WORM. The initial comparison favored CD-ROM with a cost savings of $63,000.00. The study determined that quality control by outside contractors was adequate. However, DMA was very concerned with ensuring that the cartographic database for a terrain avoidance system, used in this study, was entirely correct. To ensure total correctness, DMA would perform quality assurance on a word for word comparison to the master data. The additional cost of this quality assurance tipped the cost in favor of using WORM technology by a margin of $113,000. DMA emphasized the point that for most types of information CD-ROM is ideal, but for some specific military systems greater measures must be taken to insure that the data is correct.

The cost savings of using CD-ROM over paper, magnetic tape and microfiche suggest that an in-house production capability does have merit.

2. Versatility

CD-ROM can be used to replace a variety of media, paper, magnetic tape and microfiche. Data that is unchanging, slow to change or archival information are ideal for CD-ROM storage and there is an abundance of these type databases in the Navy and government. Its indexing features allow for

faster retrieval of information improving productivity of individuals.

3. Security of Data

There has been no production of classified information on optical media, which already limits the Navy's use of optical technology. To date no vendor has the security clearances nor developed a plan to produce classified documents on optical media. Developing an in-house production capability would allow the Navy to expand their use of optical technology to included classified material. The Navy can provide security requirements necessary to protect sensitive information and expand their use of CD-ROM by storing classified material that is static and has large distribution like the Nuclear Weapons Management Manual.

4. Turn Around Time

Vendor turn around times for producing CD-ROM have continued to improve. Depending on the vendor's work load, a CD-ROM can be produced in one, three or seven day turn around time. As the time is compressed, the fee is increased significantly. With an in-house production facility the Navy does not have to rely on the vendor's time table for producing a CD-ROM. Additional fees for shorter delivery times will not be required. This will allow the user more flexibility in schedule and budget.

IV. SUMMARY

A. CONCLUSION

Optical technology development in the Navy is still in the exploratory stages. It must not remain there. A coordinated effort must be organized within the Navy and the resources committed to develop this technology. Funding remains the critical issue. Currently, funds are not available to continue to support the TOPS program or expand it. Top level Navy management must make a decision to find the resources necessary to continue the development and support of optical technology. If not, the Navy will continue to operate well below its potential.

In developing an in-house production capability, barriers presented earlier must be overcome. If the Navy pursues the full use of optical technology, an in-house production capability will be necessary to provide the support required to produce CD-ROM on a regular basis at the lowest cost. While the Navy has not identified the technical knowledge base to support a CD-ROM manufacturing capability today, commands such as NPPS and the Navy Regional Data Automation Centers (NARDACS) have the root knowledge to develop the expertise.

An increased demand would naturally occur with the distribution of CD-ROM players to the fleet, allowing a broader user base to realize the benefits and potential uses

of optical storage, retrieval and access. Once the distribution is complete and users have had an opportunity to use the work stations, demands for new CD-ROM products should rise rapidly.

B. RECOMMENDATIONS

A coordinated plan of action needs to be formulated by the Department of Navy Information Resource Management (DONIRM) involving, at a minimum, NPPS, NAVDAC, NAVSUP, NAVSEA, NAVMASSO and SPAWARS. Throughout this research, lack of strategic plans for information systems development were encountered, with the exception of NAVSUP. Such plans are required to focus the Navy's energies toward improving and upgrading its' technical capabilities.

One of the most difficult areas of this research was trying to understand the relationships between chain of command in the information systems organization and the chain of command in functional organizations. Many commands from diverse areas come under a functional but not administrative chain of command. These confusing relationships made defining a clear tasking of responsibilities frustrating. This emphasizes the need to clarify the direction of information system programs in general and the development of optical technology in the Navy specifically.

It is clear from the previous chapters, that the demonstrated versatility of optical storage can benefit the

Navy. Continued conversion of paper, microfiche and tape to optical storage should continue to be a goal for the Navy. In an age where fewer people will have to produce more, storage and retrieval systems must support a more productive Navy. In order to move forward toward the "Paperless Ship" several commands must coordinate their efforts. To implement an in-house production capability the following responsibilities should be divided between various commands. Some of these responsibilities are already being performed by commands or contained within command mission statements. However, the process needs to be accelerated, coordinated and formalized.

The Department of Navy Information and Resource Management should host a conference with representatives from commands within the Navy that are already using or plan to use optical technology. This conference should present an overview of where the industry stands, where the Navy stands, and where the Navy wants to be in the next three to five years. One of those goals should be to develop an in-house CD-ROM production capability.

SPAWARS is the program manager for the SNAP I/SNAP II installations and is the Navy's ADP hardware systems command. They also direct the TOPS program which outfits fleet units with optical technology work stations. SPAWARS should therefore take the lead in the development of an in-house production capability. SPAWARS should be tasked by the

Director of Information Systems with developing new uses for CD-ROM storage. This would be coordinated with NAVMASSO who oversees software design for supply support in the shipboard Navy and Fleet Material Support Office (FMSO) who oversees software design for the supply shore community. SPAWARS would monitor developments in private industry in both software and hardware and initiate plans to keep the Navy current with respect to the growth of optical technologies. SPAWARS should also be responsible for providing information to the fleet and collecting feedback from the user on performance of existing system features and identifying future needs.

Navy Publishing and Printing (under direction of NAVSUP) would be in charge of the actual production and distribution of CD-ROM products and updates on a quarterly basis. They already have the distribution portion as part of their charter and with the development of optical technology production they would have to convert most of their conventional printing facilities to optical mastering or duplicating facilities. NPPS is currently exploring the possibility of becoming a duplicating facility, which would take the glass master produced by the commercial vendor and produce the duplicates required for distribution. This additional capability would give the Navy control over two of the three phases involved in CD-ROM duplication and distribution. Adding production should be the next logical step.

NAVDAC should determine the technology standards that will be applied to optical technology in the Navy. They should be participating in standard committees developing optical, format and media standards. This is a role consistent with their mission statement.

With tighter budgets and fewer personnel, the Navy must explore and develop technical capabilities that will make individuals more productive. Optical technology is a key to increasing that productivity. Top level Navy management should commit the resources that move the Navy toward the "Paperless Ship" and automated technical libraries. The funding should be used to achieve the following goals:

- Establish a fully operational CD-ROM production facility.
- Distribute optical work stations to fleet units and shore stations.
- Distribute products such as FEDLOG and HMIS.
- Educate the user on the benefits of optical technology.
- Produce technical publications, instructions, and forms on CD-ROM and distribute.
- Establish the Office of Naval Research and/or the Naval Postgraduate School as leaders in research for new uses for optical technology.

Because of the rapid advances of optical technology DONIRM should chair quarterly meetings among the players mentioned above to evaluate progress towards automation. DONIRM should established a time table for the accomplishment of these outlined goals. It is important that the Navy make funds available now to establish an in-house optical production

facility. This would enable timely updates with significant cost savings over commercial prices. It would allow for production of classified information. By the time a site is selected, plans approved, facilities built, training completed and operations begin, the user base will have expanded and the demand for products using CD-ROM will be high enough to make effective use of such a facility.

A follow on study should research the requirements for setting up a CD-ROM production facility, including location, determining building requirements and manning issues.

LIST OF REFERENCES

1. Telephone conversation between Carl Aspten, NOAA, and the author, October 6, 1988.

2. Smith, Greg G., "The In-House CD ROM Publishing Movement," CD PUBLISHER NEWS, Meridian Data Newsletter on CD ROM Publishing, Vol. 2, No. 3, p. 6, September 1988.

3. Department of Logistics Services Center, Office of Scott Bostic, letter dated January 10, 1989.

4. Dissemination of Information in Electronic Format to Federal Depository Libraries, PROPOSED PROJECT DESCRIPTIONS, p. 13, June, 1988.

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