Evaluation Report

OFFICE OF THE INSPECTOR GENERAL

EVALUATION OF AUTOMATED DOCUMENT CONVERSION IMPLEMENTATION

Report No. 96-153 **June 10, 1996**

DEPARTMENT OF DEFENSE

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Acronyms

ADCS	Automated Document Conversion System
CAD	Computer-Aided Design
CALS	Continuous Acquisition and Life-Cycle Support
DLA	Defense Logistics Agency
DPS	Defense Printing Service
DUSD(L)	Deputy Under Secretary of Defense (Logistics)
DXF	Data Exchange Format
IGES	Initial Graphics Exchange Specification
JEDMICS	Joint Engineering Drawing Management and Information Control System
OASD(C^3I)	Office of Assistant Secretary of Defense (Command, Control Communications, and Intelligence)
PC	Personal Computer

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
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Report No. 96-153

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MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION AND TECHNOLOGY
ASSISTANT SECRETARY OF DEFENSE FOR COMMAND, CONTROL, COMMUNICATIONS AND INTELLIGENCE
DIRECTOR, DEFENSE LOGISTICS AGENCY
DIRECTOR, DEFENSE INFORMATION SYSTEMS AGENCY

SUBJECT: Evaluation of Automated Document Conversion Implementation (Project No. 6PT-5003)

Introduction

We are providing this report for information and use. By agreement with the Principal Deputy Under Secretary of Defense for Acquisition and Technology, we evaluated the concerns raised by Congressman Hunter, Chairman of the Subcommittee on Military Procurement, House Committee on National Security, and a contractor, AUDRE, Inc., regarding an Automated Document Conversion System (ADCS) for engineering drawings. AUDRE, Inc., was one of the vendors whose software the Defense Printing Service (DPS) assessed as a candidate for the DoD ADCS. The Chief Executive Officer of AUDRE, Inc. told Congressman Hunter that the Defense Logistics Agency (DLA) was not buying the AUDRE automated document conversion system even though DPS assessed it as the best candidate system. In the National Defense Authorization Act for Fiscal Year 1996, the conferees expressed their concerns that DoD was not making progress to achieve "major cost savings" through adopting the automated document conversion technology. Congressman Hunter specifically questioned why the DoD was not using a previous $20 million appropriation to automate the conversion of engineering drawings.

Evaluation Results

We determined that:

o Limited demand exists for conversion of legacy hard copy engineering drawings to vector format.

o The state-of-the-art in automated document conversion technology has not progressed to the level that allows an agency to convert a rasterized drawing into its vector equivalent without human intervention.

o The DoD has developed sound policies and an effective strategy through which to implement automated document conversion in a cost-effective manner.

o The DoD has prudently expended document conversion funds.

Evaluation Objective

Our objective was to evaluate the degree to which DoD has implemented automated document conversion of engineering drawings. Therefore, we examined:

o whether demand exists for automated document conversion of engineering drawings,

o the state-of-the-art in automated document conversion technology and whether the technology is cost-effective,

o whether DoD has established automated document conversion policy that will ensure the cost-effective conversion of engineering drawings, and

o whether DoD has prudently applied automated document conversion funding.

Scope and Methodology

The scope of our evaluation included a review of document conversion within the Continuous Acquisition and Life-Cycle Support (CALS) Joint Engineering Drawing Management and Information Control System (JEDMICS) Program Management Office and at field agencies. We interviewed agency officials and observed agencies' document conversion activities. We also reviewed the Automated Document Conversion Master Plan published by the Office of the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) (OASD[C^3I]). We began the evaluation October 23, 1995, and completed it December 21, 1995.

We attended the CALS International Expo 95. We visited the Office of the Deputy Under Secretary of Defense (Logistics) (DUSD[L]), who recommended we contact specific organizations that are involved first-hand in document conversion. We met with representatives from the JEDMICS Program Management Office; AUDRE, Inc.; the Oklahoma City Air Logistics Center; DPS at Port Hueneme, California; and the Naval Undersea Warfare Center at Keyport, Washington. We also met with the ADCS action officer from the Headquarters DPS Plans, Policy, and Technology Assessment Office (Enclosure 2).

Three basic legacy document types within DoD are subject to conversion: technical publications, maps, and engineering drawings. Because the congressional concerns focus on the conversion of engineering drawings, we only evaluated the DoD efforts to convert legacy engineering drawings.

Prior Audits and Other Reviews

Since June 1994, three Inspector General Reports have related to automated document conversion of data into digitized format. Enclosure 1 discusses the prior reports.

Background

DoD has millions of legacy weapon systems drawings in hard copy format. DoD uses some of these documents in weapon systems' upgrades and in the development of new weapon systems. To edit drawings for upgraded or new weapon systems, agencies must be able to use the drawings in computer-aided design (CAD) systems. Before agencies can use these documents in their CAD systems, they must convert the documents to a digital format that a CAD system can edit. To convert these documents, engineers may have to spend numerous hours to manually trace a scanned image of a drawing or completely reconstruct a drawing. Congress believes that DoD is currently using thousands of workstations to convert legacy documents in this manner and that DoD is spending hundreds of millions of dollars a year to convert these documents.

In FY 1994, Congress appropriated $14 million to the Defense Logistics Agency to competitively procure an ADCS. Congress believed that after scanning a document, an ADCS would eliminate the need for further human intervention in the conversion process. The ADCS could cut conversion costs by reducing the labor needed to convert documents. Therefore, agencies would be able to efficiently convert hard copy drawings or drawings on aperture cards (punched cards on which a microfilmed document is mounted) into intelligent digital files using automated rather than manual methods. The data file output by the ADCS was to follow the standards of the CALS initiative.

CALS is the DoD and industry technological initiative to integrate and use automated digital technical data for weapon systems acquisition, design, manufacture, and support. The objective of CALS is to facilitate the transition from the current paper-intensive weapon systems acquisition to an environment that provides for the generation, exchange, management, and use of digital data. An ADCS would provide a more cost-effective conversion of hard copy engineering drawings into this intelligent digital technical data instead of conversion through manual processes. DoD could then use this intelligent digital data to reduce weapon system acquisition times and costs. DoD has adopted a two-stage process to convert hard copy drawings to an intelligent digital format.

The first stage of the conversion process is to scan the drawing to create a digital raster file of the drawing. A raster image is a bit-mapped representation of a drawing: a digital photograph. The degree of resolution is measured in dots per inch. Raster images can only be edited by adjusting the values of individual dots; therefore, they do not provide an editable CAD-ready file. They also require human interpretation as do hard copy drawings and drawings on aperture cards. However, raster files are good for archiving and for print-on-demand requirements.

The second stage of the conversion process converts the raster file to a vector format. A vector file is the presentation or storage of images as sequences of line segments. These data files consist of geometrically accurate and precise representations of the product, together with associated annotations such as dimensions and tolerances. Vector files can be scaled, which means one can zoom in on the details of a drawing. Also, they are more easily edited than raster files. Creating a vector file requires converting the lines and arcs in a scanned bitmap to the equivalent structure in a CAD system. Before automated document conversion systems, agencies were only able to do this conversion by manually tracing or reconstructing the drawing. The intent of the ADCS initiative was to offer a system to automatically (without human intervention) convert a scanned raster image to a vector format.

Toward that objective, DLA sponsored a state-of-the-art assessment through the DPS in April 1994. DPS conducted this assessment to identify candidate vendor automated document conversion technology packages that convert technical publications, maps, and engineering drawings. The assessment included six vendors who offered products able to automatically convert engineering drawings to vector format. Of the six vendor products, DPS assessed the AUDRE Automatic Conversion System as the best candidate engineering drawing ADCS. DPS would later test the AUDRE Automatic Conversion System for Congress.

In FY 1995, Congress appropriated $20 million to DoD to implement the ADCS for engineering drawings Defense-wide. Congress also directed that the OASD(C^3I) establish and implement a master plan for all acquisitions of automated document conversion systems, equipment, and technologies.

Between July and November 1994, DPS tested the AUDRE Automatic Conversion System. The test showed automation-assisted labor savings could result from using the AUDRE Automatic Conversion System to convert engineering drawings to vector format. However, DPS added that automated document conversion was not mature enough to completely replace trained engineers with production operators. After DPS tested the AUDRE Automatic Conversion System, it stored the tested AUDRE software packages at various DPS locations. However, these systems were not added to the DPS inventory for use in document conversion because of a lack of user requirements according to DPS.

Discussion

Demand for Automated Document Conversion. Our evaluation of automated document conversion began with determining whether the universe of documents eligible for document conversion contains any demand for vectorization of legacy hard copy engineering drawings.

DoD estimates that as many as 100 million engineering drawings exist. The universe of engineering drawings includes architectural engineering, electrical engineering, and mechanical engineering drawings. OASD(C^3I) officials stated that no credible estimate of organization records eligible for conversion exists.

However, DoD estimates that only 10 percent of raster engineering drawings require conversion to vector format. See Figure 1. OASD(C^3I) officials indicate that the many technology-related marketing claims may have generated an artificial demand for conversion of DoD paper records to digital media formats.

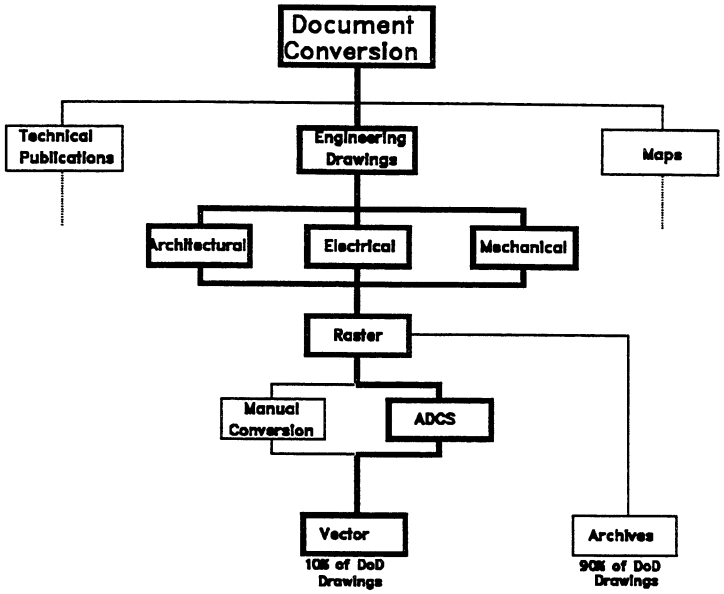

Figure 1. DoD Estimate of Engineering Drawings Requiring Conversion to Vector Format

None of the agencies we visited expressed a requirement to bulk convert documents to vector format; they implemented conversion requirements as needed. One agency even found bulk conversion of legacy hard copy documents to digital *raster* format to be unnecessary because it no longer uses many of the drawings. Therefore, agencies must first determine which of their legacy drawings in general they might use, if any, before they consider which drawings they might need to convert to a vector format.

According to OASD(C^3I), deciding which documents to convert is crucial to any conversion project. Military mission and business requirements and a business case that clearly explains the functional and economic benefits anticipated from conversion will guide the conversion decisions. In addition to military mission and business requirements, these decisions include the timing of automated conversion and the justification for automated conversion. The decisions are delegated to responsible functional and DoD Component officials.

Conclusion. Limited demand exists for conversion of legacy hard copy engineering drawings to vector format.

Cost-effectiveness of ADCS Technology. To evaluate ADCS technology in the conversion of engineering drawings from raster to vector format, we examined current available conversion technology and the future of automated document conversion technology. We also looked at the minimum operator skill and knowledge required to provide a cost-effective conversion, the operating system and hardware platform requirements that will most cost-effectively use current DoD platforms within the engineering community, and which data format standards the ADCS should produce to provide a cost-effective digital file for use in the acquisition life-cycle.

Current Conversion Technology. To convert a hard copy document to a vector file, DoD has adopted a two-stage process. The first stage of conversion establishes an interoperable baseline digital raster format, allowing agencies to share information electronically. The second stage further processes the digitized image into a more complex digital vector format if required by the target application. This flexible two-stage approach extends the potential for reuse of a converted document to satisfy different user requirements for the same document. Within this two-stage conversion process, we identified several steps necessary to achieve a quality CAD-ready vector file that accurately depicts the original drawing.

The first step is to scan the hard copy drawing or aperture card to create a digital raster image. The second step involves a quality assurance function to ensure the quality of the scanned raster image. This process may involve deskewing and despeckling the image. The third step is to convert the raster file to a vector file. This step identifies and captures the different parts of the image. This step in the conversion process is automated, which produces an initial vector image that the ADCS operator can then edit. In the fourth step, the ADCS operator performs a quality assurance check and edit of the initial vector image. The ADCS operator would then pass the vector file to the using engineer for a final quality assurance check to ensure that all parts of the image were captured and converted correctly. This step may involve editing objects or symbols that the ADCS may have misrecognized in the third step and the ADCS operator missed or was unable to interpret in the fourth step. Since this fifth step should be done by a subject matter expert, such as an engineer, it could most cost-effectively be accomplished in the using agency's target application that the engineer is familiar with, such as AUTOCAD. See Figure 2.

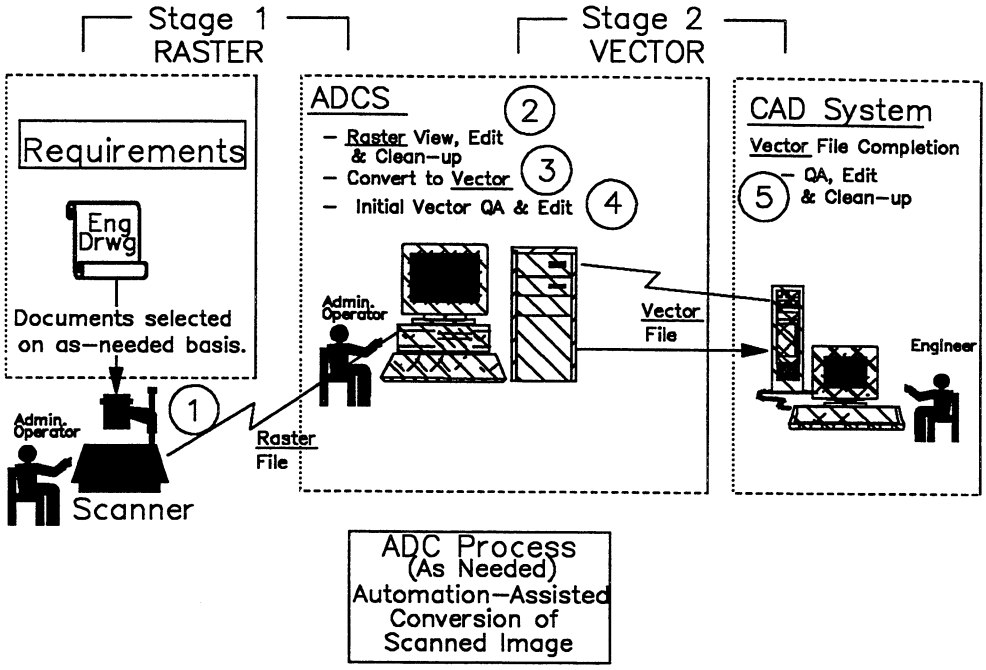

Figure 2. Two-stage, Five-Step Automated Document Conversion Process

The condition of the source document and the type of drawing determine the amount of human interaction by the ADCS operator and the subject matter expert. Because the second, fourth, and fifth steps require the interaction of ADCS operators and subject matter experts, such as engineers, to generate an acceptable CAD-ready file, an ADCS is considered to provide only an automation-assisted conversion capability rather than a fully automated conversion capability. However, one of the agencies we talked with that uses production operators (as opposed to engineers) stated that prior to the AUDRE Automatic Conversion System, it would not convert engineering drawings. The agency said that the AUDRE system is its only option for CAD-ready conversions. The only current alternative to automation-assisted drawing conversion is tracing or completely reconstructing a drawing. Another agency, which was not familiar with the AUDRE Automatic Conversion System, continues to use manual conversion methods.

AUDRE executives explained that the sole purpose of its ADCS is to be a conduit to other applications, such as AUTOCAD, so that engineers can complete the conversion and get on with their upgrades and changes more quickly. An ADCS cuts the conversion time so that engineers can access an editable file in a more timely manner so that they could then change and upgrade a drawing in their target CAD environment. One agency plans to use the AUDRE Automatic Conversion System to provide one of its customers a Data Exchange Format (DXF) file to convert to another format using another application. Another agency has been using AUDRE for 2 to 3 years as a

routine part of its production operations. The agency provides its customers with an editable vector file so that the customer engineers will not have to redraw the drawing from scratch. The agency explained that a conversion process that would take an engineer weeks to complete using tracing methods would only take it a day using the AUDRE Automatic Conversion System.

Future Conversion Technology. According to experts in electronic document conversion technology, fully automated document conversion systems are not likely to be developed soon. Therefore, the engineering industry is likely to be using automation-assisted conversion technology for some time.

ADCS Operator Skill and Knowledge. The ADCS Test found that blue collar administrative personnel with basic computer skills and no engineering drawing experience can attain the skill necessary to cost-effectively convert engineering drawings. Compared to the manual alternatives, the ADCS Test Report indicated that the most productive administrative ADCS operators achieved better throughput times and quality than either the professional engineers or the commercial conversion operators using manual methods. The report added that costs to convert a typical drawing vary from $200 if redrawn by engineers to $119 if converted through existing commercial sources to $85 if converted by experienced operators using automation-assisted conversion techniques. The report estimates that labor savings range from 20 percent to 50 percent over the manual redraw methods that professional engineers use.

One agency has been using the AUDRE Automatic Conversion System for the last 2 to 3 years. Most of its operators are high school graduates with a printing operation background rather than a computer or data entry background. The operators learned the system in about 3 weeks. The agency stated that its operators have converted in a day what their customer agency engineers would take weeks to convert using manual tracing methods.

ADCS Operating System and Hardware Platform Requirements. The AUDRE Automatic Conversion System can operate on a Personal Computer (PC) (Sun Solaris operating system) or UNIX (Hewlett Packard or Sun) platform. The hardware platform is not a factor in producing a CALS-standard vector output. In addition, the ADCS can output the vector file in the appropriate format for the target application. However, AUDRE executives stated that the PC platform presents memory management problems. They added that their software can co-exist on a system already containing another application such as AUTOCAD.

ADCS Digital Vector Data Format Standards. The digital data produced by the ADCS was required to follow the CALS digital data format standards. The Initial Graphics Exchange Specification (IGES) is the CALS digital vector format standard for CAD system engineering drawings.

The IGES file format treats the data required to describe and communicate the essential characteristics of physical objects as a file of entities. Each entity is represented in an application-independent format, which can be mapped to and from a native representation of a specific CAD system. Because IGES is

available in five versions, problems can result when trying to transfer IGES files between different CAD systems. The transfer can result in mis-mappings and the loss of data.

OASD(C^3I) officials state that DoD recognizes de facto standards until formal standards are developed and adopted by recognized standards organizations. The de facto industry CAD standard format is DXF. DPS chose to use the DXF format during the ADCS test instead of the IGES format because it is the most acceptable common CAD file format within the engineering industry.

The AUDRE Automatic Conversion System can readily output to either format. However, the two agencies we visited that use the AUDRE Automatic Conversion System produce digital data in the DXF format instead of the IGES format. These agencies use the DXF format because it is a neutral file format, which the end-user can convert to any other format.

Conclusion. The Automated Document Conversion System provides a cost-effective automation-assisted conversion capability using administrative operators. Therefore, the ADCS can provide significant labor savings over highly skilled engineers manually tracing or reconstructing drawings. The potential for savings depends partly on whether an agency has a sufficient demand to convert documents to vector format (See "Demand for Automated Document Conversion," page 8).

Automated Document Conversion Policy. We reviewed whether DoD has established an automated document conversion policy that will ensure the cost-effective conversion of engineering drawings.

In the FY 1995 Defense Appropriation Act, Congress directed the OASD(C^3I) to establish and implement a master plan for all acquisitions of automated document conversion systems, equipment, and technologies. In April 1995, OASD(C^3I) published the Automated Document Conversion Master Plan (the Master Plan).

The Master Plan provides strategic guidance for all automated document conversion acquisitions within DoD. It focuses on conversion from paper or microform to digital formats. The Master Plan addresses three main areas:

o the "DoD Conversion Environment," which summarizes the mission and business needs for automated document conversion;

o the "DoD Conversion Strategy," which describes the DoD strategy for achieving a consistent approach to automated document conversion; and

o "DoD Roles and Responsibilities" applicable to automated document conversion.

One theme of the "DoD Conversion Environment" is for agencies to "follow existing policy." The Master Plan views document conversion as an activity within the "records management" business process. It also states that the requirement or business need for document conversion must be justified using existing Corporate Information Management principles and automated information system life-cycle management policy.

One component of the "DoD Conversion Strategy" focuses on the management of automated document conversion system acquisitions and requirements. This management component provides agency guidance to determine whether a proposed automated document conversion acquisition meets operational requirements and produces sufficient cost savings. This guidance provides agencies with decision criteria in four areas: Requirements Determination, Cost Justification, Document Candidate Selection, and Technical Capability. Agencies should consider these criteria before deciding to proceed with automated document conversion.

The Office of the DUSD(L) has also taken steps to ensure the cost-effective conversion of engineering drawings. The Office of the DUSD(L) issued a data call in August 1995 to the Services regarding what their experiences have been with document conversion, their data conversion requirements, their experience with the cost-effectiveness of document conversion, and what software and hardware they use in document conversion. The Office of the DUSD(L) will also decide whether procuring and fielding a PC-based ADCS is worthwhile given the preponderance of UNIX workstations in the DoD engineering community.

Congress has requested that the Office of the DUSD(L) provide it the results of these efforts. Specifically, the report will address:

o the logistics community's requirements and strategy for raster to vector conversion,

o the drawing document universe in the field,

o the number of engineers in the field,

o the level of existing UNIX and PC platforms, and

o an acquisition plan for the software and hardware and who the vendors will be for each.

Conclusion. The DoD has developed sound policies and an effective strategy through which to implement automated document conversion in a cost-effective manner.

Application of Automated Document Conversion Funding. We reviewed whether DoD has applied automated document conversion funding in a prudent manner.

With the $14 million appropriated to DLA in 1994, DLA procured ADCS hardware and software and met other costs, such as salaries, training, travel, and conversion, associated with its evaluation of the ADCS technology. Also, DLA funded an independent operational appraisal of the ADCS technology by the Defense Information Systems Agency Joint Interoperability Test Command.

Of the $20 million FY 1995 appropriation, DLA allocated $10 million for procurement and $10 million for operation and maintenance. As of December 8, 1995, DLA had spent $7.5 million of the procurement allocation to procure ADCS hardware and software. In May 1995, DLA procured 50 AUDRE software packages and 34 Hewlett Packard workstations for some field agencies to use in their document conversion efforts. In the first quarter of FY 1996, in response to requests from Congress to evaluate raster to vector conversion products in the field, DLA procured an additional 20 AUDRE workstation-based systems, 100 AUDRE PC-based systems, and 100 each PC-based systems of four other vendors for the Services to evaluate.

Also, DLA provided $2.2 million of the Operation & Maintenance allocation to one specific agency to convert its documents from raster to vector. DLA had requested the Services determine whether or not they had requirements for raster to vector conversion; only one Service responded. As a result, DLA wants to spend the remaining $7.9 million on raster to vector conversion within a single weapon system program.

Conclusion. DoD has prudently expended document conversion funds.

Management Comments

We provided a draft of this report to you on April 25, 1996. Because this report contains no findings or recommendations, written comments were not required and none were received. Therefore, we are publishing this memorandum report in final form.

We appreciate the courtesies extended to the evaluation staff. If you have questions on this report, please contact Mr. Kenneth H. Stavenjord, Technical Director, at (703) 604-8952 (DSN 664-8952) or Mr. Gregory R. Donnellon, Evaluation Project Manager, at (703) 604-8946 (DSN 664-8946). See Enclosure 3 for the report distribution. The evaluation team members are listed inside the back cover.

Robert J. Lieberman
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Enclosure

Summary of Prior Audits and Other Reviews

Three Inspector General, DoD reports covered issues related to this evaluation.

Report No. 95-060, "Digital Mapping, Charting and Geodesy Data Standardization," December 19, 1994, found that the Defense Mapping Agency had taken positive actions to standardize digital mapping, charting, and geodesy data. The purpose of standardization was to promote electronic transfer between military systems and to promote system compatibility and interoperability. The report made no recommendations for corrective actions and no comments were made in response to the final report.

Report No. 95-043, "Management of the Digital Production System Development at the Defense Mapping Agency," November 28, 1994, found that the Agency did not identify customer requirements, did not analyze the cause of software problems, and did not correct configuration management deficiencies. The report recommended that the Defense Mapping Agency improve its product specification development and revisit its problem reporting. The report also recommended corrective actions on configuration management procedures and the Digital Production System. Finally, the report recommended a Milestone IV (Major Modification Approval) review of the Digital Production System. Management concurred with the recommendations regarding program management and agreed to review the Digital Production System.

Report No. 94-INS-05, "Management of Digitized Technical Data," July 8, 1994, found a lack of management and clear and consistent guidance from DoD. The report specifically criticized management of the CALS initiative because CALS was not defined as a strategy or as a program. The lack of definition created an ineffective management structure, late allocation of funds, a lack of policies on reimbursement for operating funds, and a lack of specific guidelines needed to acquire and manage digitized technical data. The Joint CALS system had similar problems. The report recommended several changes, including greater structuring of CALS and Joint CALS management, writing action plans for implementation, changes to regulations, greater oversight, and changes to data standards. DoD agreed to most recommended changes; however, the DoD rejected the recommendation to modify the funding of CALS by removing the program from the Defense Business Operations Fund and moving it under direct appropriations.

Organizations Visited or Contacted

Office of the Secretary of Defense

Office of the Deputy Under Secretary of Defense (Logistics), Washington, DC

Department of the Navy

Naval Undersea Warfare Center, Keyport, WA
Defense Printing Service, Washington, DC

Department of the Air Force

Oklahoma City Air Logistics Center, Tinker Air Force Base, OK

Other Defense Organizations

Defense Printing Service, Port Hueneme, CA
Program Management Office, Joint Engineering Drawing Management and Information Control System, Arlington, VA

Non-Government Organization

AUDRE, Incorporated, San Diego, CA

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House Subcommittee on National Security, Committee on Appropriations
House Committee on Government Reform and Oversight
House Subcommittee on National Security, International Affairs, and Criminal Justice, Committee on Government Reform and Oversight
House Committee on National Security
House Subcommittee on Military Procurement, Committee on National Security

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