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NESD CAE FACILITY MINIMAL IMPLEMENTATION PLAN (JUNE 1982)

HENRY S. AMES

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ABSTRACT

In conjunction with other divisions in the EE Department, the Nuclear Energy Systems Division is developing a Computer-Aided Engineering (CAE) capability. Some of our needs in areas such as drafting, PC design, and IC design can be satisfied with existing turnkey systems. Many of our other needs, including modeling, analysis, document management and communication, software development, project management, and project communication will require the gradual development of an expanded computing environment. The purpose of this document is to describe our initial plans to implement a CAE facility.

1. INTRODUCTION

1.1 GENERAL BACKGROUND

The Electronics Engineering Department at Lawrence Livermore National Laboratory (LLNL) has been successfully using a variety of CAD/CAM tools and other computer aids for a number of years. Separate turnkey systems have been available for standard drafting functions and for integrated circuit design. The fabrication shop operates numerically controlled tools for wire wrapping, drilling, and panel punching. These systems have increased the productivity of design and drafting personnel, reduced turn-around time, and produced better products.

Some other computer aids have also been available to assist engineers in the solution of engineering problems in areas such as power systems analysis and electronic circuit analysis. These aids have typically been available on the Laboratory's mainframe computers and usually do not couple with any of the other aids. Still, their effectiveness has been sufficient to encourage continued use and to suggest that further benefits could be derived from more extensive computer aids.

Currently, however, the growing complexity and scale of problems which face our engineering staff, coupled with the great national demand for engineers, mandates that additional tools be provided. The success of CAD/CAM provides the impetus for applying computers to the entire engineering process. We are currently developing plans for a more integrated and extensive set of tools utilizing the current and expected products from today's rapidly developing computer technology.

1.2 THE CAE PROJECT IN NESD

The Nuclear Energy System Division of the Electronics Engineering Department furnishes the programs it supports with high quality electronic engineering and supports and maintains program facilities in a safe, efficient manner. The primary customer served by NESD is the Nuclear Weapons Program. NESD's direct support to the Program is through the Nuclear Design Program and Military Applications Program. In addition, NESD supports other organizations which also support the Weapons Program. These include the Precision Engineering Program; Engineering Sciences and Materials Fabrication Divisions of the Mechanical Engineering Department; H-Division in the Physics

Department, the Non-Nuclear Ordnance Program, and the Chemistry and Material Sciences Department.

In conjunction with other divisions in the EE Department, NESD is developing a Computer-Aided Engineering (CAE) capability. Some of our needs in areas such as drafting, PC design, and IC design can be satisfied with existing turnkey systems. Many of our other needs, including modeling, analysis, document management and communication, software development, project management, and project communication will require the gradual development of an expanded computing environment.

A number of different areas which could benefit from computer aids have been identified. These include:

* design/drafting
* engineering modeling and analysis
* manufacturing
* software development
* project management
* project communication

Each of these areas is discussed next in more detail.

Historically, the design/drafting area has been the center of CAD activity, where the acronym has been used to mean both computer-aided drafting and computer-aided design. The bulk of the commercial systems to date have been aimed at the full-time design and drafter, whether the field is schematic drafting, printed circuit board design, or integrated circuit design. Typically, these tools have <u>not</u> been directed toward the engineer or technician.

Today, the need for this traditional design and drafting continues to exist, and commercial systems are increasingly powerful and productive, with a growing capability in the design area. In addition to these systems, there is a strong desire for design systems for use by engineers and technicians. Superficially, such systems bear some resemblance to computer-aided drafting systems because a circuit schematic is frequently one of its products. However, two key differences separate it from traditional CAD systems. First, these systems must be easy to use by a casual user--the engineer--with minimal training. Second, the database of the system must be sufficiently rich to allow the design to couple effectively with analysis tools and CAM systems.

We currently use an in-house system, the Engineers' Design Station, for this purpose. Its success over the last 1.5 years supports continuing expansion of this type of capability in coming years. We are currently evaluating the extension of this system for use by engineers in designing gate arrays. The system would serve as a "front end," with the schematic-level design being transferred to our solid-state group for implementation.

Modeling and analysis are becoming more important components of the engineer's job. The high cost and elapsed time for building physical models are increasingly unacceptable--and building such models is frequently impossible. For example, simulation proved an invaluable tool in analyzing the designs of a multimillion dollar power supply system procured from external vendors. In order to stimulate increased use of both modeling and simulation, good tools must be made available in a convenient way.

Capabilities that are needed include:

* logic analysis
* controls analysis
* systems identification and modeling
* systems analysis
* electromagnetic fields analysis
* circuit analysis
* signal processing analysis
* reliability and fault analysis
* software systems modeling

Most of our manufacturing is limited to a few copies of a given design, rather than mass production. Thus, needs for computer-aided manufacturing differ somewhat from many commercial companies. We currently support a small number of numerically controlled machines, as well as generation of manufacturing aids, such as artwork. Probably the major requirement is on the design systems: they need to provide appropriate input for both in-house and outside CAM systems.

Software development is an increasingly important part of our engineering work. Yet almost no facilities or tools are in place to assist in this development. Frequently, software must be developed on hardware which is sufficient for the purposes of the application, but which is not sufficient for effective software development. And even more often, no development tools beyond an editor and an assembler or compiler are available. The success of some current program development systems underscores the need for more effort in this area.

Increasing complexity of projects, tight time schedules, and budget constraints all point to the need for continued use of effective computer aids for project planning, project management, and financial control. Accessibility to pertinent data, computer aids, and appropriate computer power are all necessary.

Finally, project communication can be enhanced by computer aids. Whether a formal electronic mail system is used or simply a shared access to engineering documents, there seems to be great potential in this area.

2. DESCRIPTION OF THE REQUIREMENT

2.1 IMMEDIATE PLAN

The philosophy of the CAE system plan calls for using major commercial products wherever possible, with local activity restricted to necessary integration work and development of key components which are not available from commercial or other sources. As a first step toward our goals of improved quality of our work and increased productivity, we are proposing the development of a Computer-Aided Engineering facility (NESCAE) based on the DEC VAX computer. The facility is shown in Fig. 1 and summarized in Appendix A. The system will provide facilities for time-sharing and immediate utilization of existing codes for signal processing, state space estimation and circuit analyses. We can also begin investigating software engineering tools.

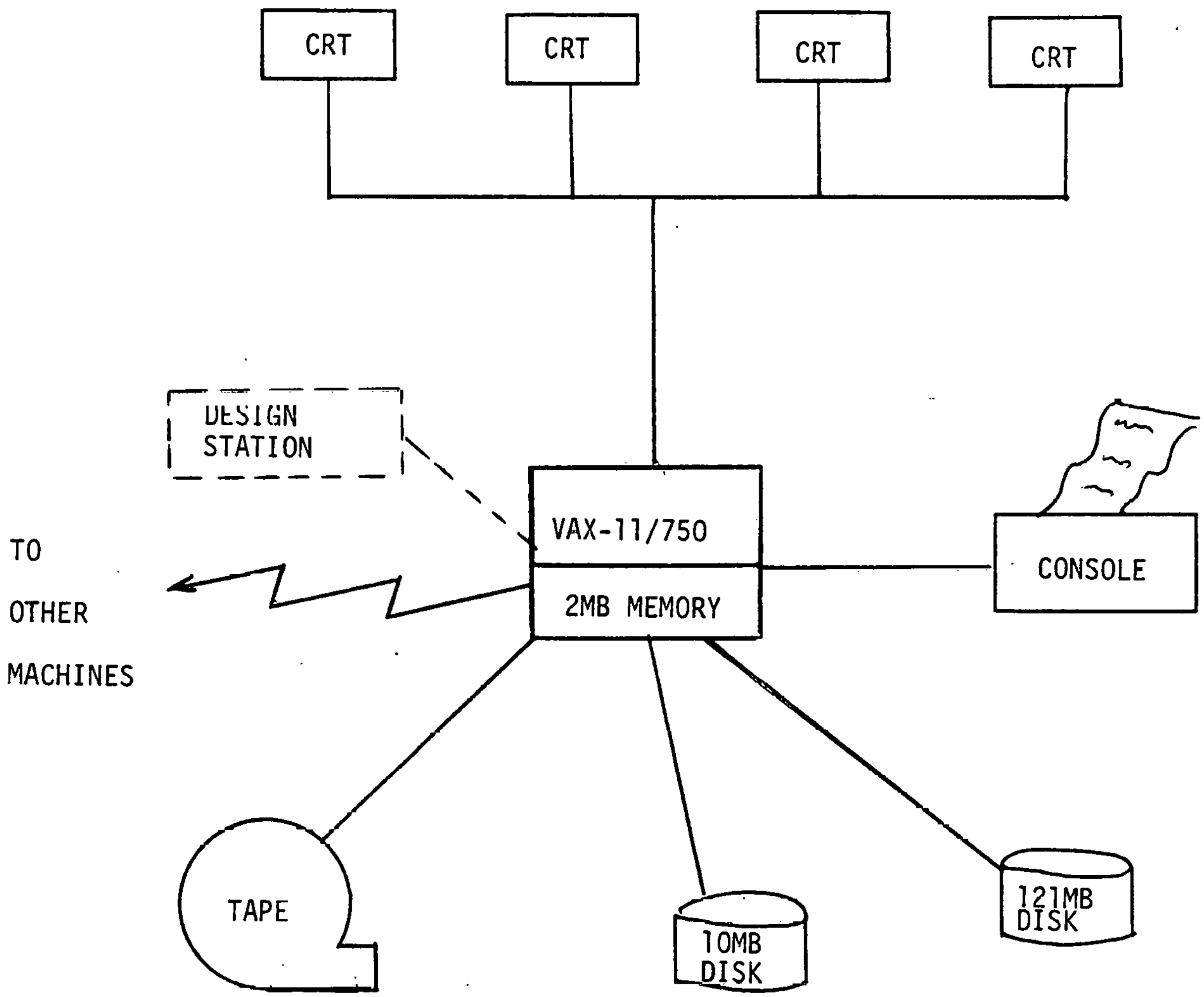

Figure 1. NESD CAE Configuration

2.2 FUTURE PLANS

Current trends in computer technology, especially in the development of more powerful superminis and in networking have prompted a system design model based on a distributed computing philosophy. We currently envision a three-tier system, consisting of large mainframes connected to 32-bit superminis which in turn are connected to a variety of terminals, ranging from simple alphanumeric terminals to sophisticated engineering workstations. The terminals will probably be connected to the superminis by some form of the developing local networking techniques which utilize coaxial cable.

The engineering workstations are a significant feature of this system, both in terms of their physical description and their intended utilization. Such a workstation might consist of a 32-bit processor on a chip (or a chip set), 30 Mbytes of Winchester-technology disk, a graphics display, 1 Mbyte of main memory, an appropriate set of interactive devices, and perhaps a floppy disk and printer. (Workstations of this type are available to some degree at the current time but should be significantly cheaper and more powerful in the next three- to five-year period.)

The sophisticated workstations are intended for use by the engineering staff--in a number of applications. First, the current Engineers' Design Station will be reimplemented to utilize these workstations. Thus, these workstations are a key part of the plan to put design aids in the hands of engineers. Second, these stations will be used for the more demanding modeling and simulation applications. These stations will be distributed throughout the engineering work areas, initially in small numbers. As this class of terminal matures in its development, it is expected to be used in greater numbers.

The requirements for graphics display are somewhat application-dependent. For many engineering applications, a resolution of 512 x 512 seems to be marginal, while 1024 x 1024 may be more than required. Roughly, 600 x 800 would seem to be a useful minimum. Color capability appears to have proved its worth in a number of applications and will probably be included in many workstations.

Additional software is the key to increased productivity. This software will be acquired, rather than developed, wherever possible. Sources include commercial companies, universities, and other government laboratories. Software is needed in essentially all of the areas discussed earlier but especially in the areas of modeling, simulation, software development, and project management.

3. SPECIFICATION OR EQUIVALENT

The minimum requirements are as follows:

The processor should have a 32-bit virtual address capability with at least 1 MB of memory. The large address space allows easier development and execution of large programs which are typical of CAE programs. The system must support a nine-track magnetic tape for communication with other computer systems. Floating point hardware is required to speed up numerical calculations which are used extensively in analyses and modeling codes.

The software required includes at least FORTRAN and a time-share multiuser system which supports the virtual address capability of the machine. The software and hardware must support execution of codes which presently run on VAX machines in order to take advantage of codes already developed for CAE functions.

4. ESTIMATED TOTAL COSTS

A summary of hardware costs and software costs for this project are as follows. The total system cost will be about $148K. The breakdown of these costs is given in Appendix A. The procurement will be 97K during FY'82.

5. TYPE OF SOLICITATION

NESD proposes to purchase a VAX-11/750 from DEC on a sole-source basis. There are several strong reasons for this sole-source:

1) Existence of CAE computer codes for a VAX. These codes include: SPICE (circuit analyses), SATER (a system identification and modeling code), FRAMIS (database management), GRAPHLIB (SIGGRAPH implementation of graphics routines), SIG (signal analyses, filtering and correlations) and PRAXIS (controls language). In addition, the design station, as currently described earlier, and LSAP (a controls program) are being transported from a PDP-11 to the VAX and will represent significant CAE tools. It is estimated that approximately 12 man-months of effort would be required to convert these codes to a different 32-bit computer system.

2) Data and code sharing. There is already a VAX within our research division which could be connected to CAE facilities via DECNET to improve data and code transfers. DECNET will also allow communications with other PDP-11 machines which are used extensively at LLNL.

6. MAJOR MILESTONES

Approximately three weeks after the implementation plan is approved the purchase order should be placed with the vendor, and the computer will be installed 90 days later. After about one month of check-out the CAE facility should be available to users who wish to begin learning how to use the system. It is estimated that significant codes for analyses and modeling (like SIG and SATER) will be available within a week of any acceptance tests. The computer will be removed in 1989.

7. SOURCES OF FUNDS

The funding sources are summarized below:

FY'82	Capital	$81.4K
	Expenses	$15.6K
FY'83	Capital	$35.0K
	Expenses	$15.9K

8. FACTORS WHICH WOULD PREVENT LEASE OR PURCHASE

There are no known factors which would prevent leasing or purchasing the computer hardware.

9. LEASE VS. PURCHASE CONSIDERATION

An analysis of estimated lease costs versus purchase costs over the anticipated lifetime of the system clearly indicates that purchase is the most economical method of procurement. Please see Appendix B for a detailed analysis.

10. IDENTIFICATION OF TELECOMMUNICATIONS REQUIREMENT

There is no telecommunications requirement.

11. LIST OF COMPUTER EQUIPMENT TO BE REMOVED

No computer equipment will be removed.

12. JUSTIFICATION OF NEED

The justification for CAE within NESD is based on the need to improve the engineer's productivity through aids which reduce the level of complexity the engineer faces and reduce the development cycle time. Productivity gains brought about by the use of CAD/CAM have stimulated a broader examination of the role which computers might play in the process. With engineering salaries increasing, in part because of the manpower shortage, and with computer costs decreasing, it will be economically reasonable to provide engineers with substantial computer power to increase their productivity. It appears that technology and economics will lead to this significant increased use of computers in engineering, computer-aided engineering, within this decade.

In addition, the systems which we are being called upon to develop are becoming increasingly complex. Stringent requirements on such things as size, power consumption, and operating environment further complicate the development process. CAE will help the engineer facing these problems. Competition for resources is making decreased activation time a necessity.

13. CRITERIA FOR SELECTION OF VENDOR

This procurement is sole-source for the reasons stated in Section 5.0.

ACKNOWLEDGMENTS

The author wishes to gratefully acknowledge that portions of the material presented, particularly in the introductory section, were taken from a document written by Lansing Hatfield et al. (UCRL 86879 "Computer-Aided Engineering--The Step Beyond CAD/CAM," November 1981) and a document written by Stan Trost (UCID 19250 "NESD Strategic Plan," October 1981).

APPENDIX A

Hardware and Software Costs

Fiscal Year		Qty.	Total Discount Price	Comments
'82	VAX-11/750, includes 121 MB fixed disk, 10 MB disk, 45 ips tape and 1 MB memory, DECNET Hardware	1	$77.4K	
	1 MB memory	1	4.0K	
	CRT terminals	4	7.5K	
	Software	1	6.3K	
	Documentation	1	1.8K	
			$97.0	
'83	Design Station	1	$35.0K	
		1		
	Terminals	2	3.9K	
	Software	1	12.0K	
			$50.9K	
	Grand Total		$147.9K	

Appendix B

Lease Versus Purchase Analysis

TO BE SUPPLIED WHEN AVAILABLE

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276-300	23.50	601-up[1]	
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